TECHNOLOGY VALUATION WITHIN THE CONTEXT OF TRANSFER COLLABORATIONS WITH CHINESE MACHINE TOOL COMPANIES

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Doctor of Philosophy

THE UNIVERSITY OF ASTON IN BIRMINGHAM

Month of submission December 1999

THESIS SUMMARY

The point of departure for this study was a recognition of the differences in suppliers' and acquirers' judgements of the value of technology when transferred between the two, and the significant impacts of technology valuation on the establishment of technology partnerships and effectiveness of technology collaborations. The perceptions, transfer strategies and objectives, perceived benefits and assessed technology contributions as well as associated costs and risks of both suppliers and acquirers were seen to be the core to these differences.

This study hypothesised that the capability embodied in technology to yield future returns makes technology valuation distinct from the process of valuing manufacturing products. The study hence has gone beyond the dimensions of cost calculation and price determination that have been discussed in the existing literature, by taking a broader view of how to achieve and share future added value from transferred technology. The core of technology valuation was argued as the evaluation of the '*quality*' of the capability (technology) in generating future value and the *effectiveness* of the transfer arrangement for best use of such a capability. A dynamic approach comprising future value generation and realisation within the context of specific forms of collaboration was therefore adopted.

The research investigations focused on the UK and China machine tool industries, where there are many technology transfer activities and the value issue has already been recognised in practice. Data were gathered from three groups: machine tool manufacturing technology suppliers in the UK and acquirers in China, and machine tool users in China. Data collecting methods included questionnaire surveys and case studies within all the three groups.

The study has focused on identifying and examining the major factors affecting value as well as their interactive effects on technology valuation from both the supplier's and acquirer's point of view. The survey results showed the perceptions and the assessments of the owner's value and transfer value from the supplier's and acquirer's point of view respectively. Benefits, costs and risks related to the technology transfer were the major factors affecting the value of technology. The impacts of transfer payment on the value of technology by the sharing of financial benefits, costs and risks between partners were assessed. The close relationship between technology valuation and transfer arrangements was established by which technical requirements and strategic implications were considered. The case studies reflected the research propositions and revealed that benefits, costs and risks in the financial, technical and strategic dimensions interacted in the process of technology valuation within the context of technology collaboration.

Further to the assessment of factors affecting value, a technology valuation framework was developed which suggests that technology attributes for the enhancement of contributory factors and their contributions to the realisation of transfer objectives need to be measured and compared with the associated costs and risks. The study concluded that technology valuation is a dynamic process including the generation and sharing of future value and the interactions between financial, technical and strategic achievements.

Key words: Value, Technology attribute, Transfer arrangement, China, Survey.

ACKNOWLEDGEMENTS

This research work would not have been possible without the generous supports of all the directors/managers from the companies visited who contributed so much of their time and knowledge. My thanks go to all the individuals. In particular, I would like to express my gratitude to the following, who offered continuous supports and provided a wealth of company information related to the research issue: David Bromige, Marketing Director (Machine Tool Technologies Association), Stephen Brittan, Managing Director, Bob Franklin, Chief Engineer (BSA Tools Ltd), Stephen Brown, Director of Business Development (Cincinnati Machines), Ken Smith, International Sales Manager, Michael Nicholson, International Sales Manager, Christopher Ford, International Project Manager (Bridgeport Machines Inc), John Brown, Managing Director (Addison Tube Forming Ltd), Stephen Lebeau, Product Strategy and Marketing Director (The 600 Group - Machine Tool Division), Bill Stone, Sales Manager (Giddings & Lewis), Zhang Weicheng, President, Li Xucheng, Deputy President (Beijing Machinery and Electricity Institute), Hong Tao, General Manager (Changcheng Machine Tool Company Ltd), Gao Changfa, Director of International Co-operation Department, Fan Zhongcheng, Deputy Director (Sichuan Machine Tool Bureau), Chen Changnian, Director of Marketing Department (China Machine Tool and Tool Builders Association), Yang Man, Sales Project Manager (Bridgeport Beijing Office).

I am also grateful to the Engineering and Physical Science Research Council for funding the research project and to Aston University for employing me to conduct the research work.

My special thanks go to Professor David Bennett and Kirit Vaidya, my supervisors, for their advice, understanding and patience, who kept me on the track, and whose helpful guidance were invaluable throughout the course of my work: my thanks always.

I am indebted to Dr. Terry Jones, for his generous help, time, comments and correction of my English. My thanks also go to Dr. Xinxin Hu, for her suggestions and assistance with inputting the survey data; to Jacqui Shine, for the provision of convenient access to computing and office facilities.

Finally, my sincere appreciation goes to the continuous support given by my family. There were hard works and efforts involved in the study, but their care and encouragement make it all worthwhile.

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CHAPTER ONE
INTRODUCTION

1.1 General Background Context of The Research

1.1.1 Rapid development of international transfer of manufacturing technology (ITMT)

International manufacturing has become one of the strategic focuses in developed economies and has witnessed rapid growth since the last decade (Chandra and Bures, 1990). Theoretically and fundamentally the reason for international manufacturing is because inevitable differences of comparative advantages exist among nations and consequently efficiency and competitiveness are created by using those advantages. Practically there are many other differences, such as the economic situation and growth, market competition and potential, factor inputs and costs etc. which may also favour manufacturing crossing countries (Blumenthal, 1987; OTA Study, 1988).

ITMT is seen as a central part in international manufacturing. In recent years technology transfer has been used increasingly within international manufacturing as a means of reaching new markets and is playing a critical role in establishing collaborative ventures between companies in developed and developing countries. The world technology trade exceeded US$200 bn in 1994, compared with US$50 bn in the mid 1980s (China Daily, 1994). The awareness of the dominant role that technology plays in improving competitive strength has inspired many less developed countries (LDCs) to have a stronger desire to buy technology from developed counties (DCs) (Marton, 1986). Given the awareness that foreign direct investment (FDI) to China is characterised as a major vehicle of international technology transfer (Casson and Zheng, 1992; Ball *et al*, 1993; Beamish and Speiss, 1993), China had approved over 332,700 foreign invested firms, pledged and realised FDI of US$592 bn and US$286 bn respectively by the end of June 1999 (People's Daily, 1999). China has been ranked the second largest recipient (after the US) of FDI flows in the world and the largest recipient in LDCs in almost every year since 1992. The annual FDI inflow of China represented over 15% of the worldwide FDI flows and 40% of the total inflows to LDCs (China Foreign Economic and Trade Year Book, 1997). The great potential for utilising FDI as an essential instrument for China's technological development has been recognised (Hayter and Sun, 1998; Young and Lan, 1997) and the number of FDI projects to China with technology transfer involvement has been rapidly increasing in recent years. Between 1979 and 1992, China signed over 7000 technology transfer contracts with foreign companies valued at almost US$48 bn (China Daily, 1993). In 1995, there were 3637 technology import contracts in China valued at US$13 bn and in 1996 both the contract number and value increased by 67% (6074) and 17% (US$15.2 bn) respectively (China Foreign Economic and Trade Year Book, 1997). It started to slow down since 1998, however, in the first half of 1999, there were still 491 contracts of technology import that were signed in China with a total value of US$3.3 bn (China-Britain Trade Review, 1999).

Meanwhile, the awareness of technology as a 'chronicle disturber' of comparative advantage (Cheanais, 1986) has also led many DCs to be more willing to transfer their technology to LDCs where comparative advantages can be captured. Efficient acquisition of technology and effective use of technology has been recognised as the crucial means for any firm to survive. More importantly, as markets are increasingly more competitive and globalised, ITMT has been used as one of the most effective means of accessing foreign markets and resources (Kiser, 1979). This is especially the case with transfers between developed and developing countries (Kaplinsky, 1990; Roessner and Porter, 1990). The mutual benefits from ITMT with suppliers gaining entry to local markets and buyers acquiring technology have actually encouraged more companies to adopt the strategy of ITMT.

1.1.2 ITMT in machine tool industry

ITMT in the machine tool industry has also increased in recent years. There are two main internal changes that lead to the fast growth of ITMT in this sector. One is that the rapid development of machine tool manufacturing technology, which has been challenging the way of manufacturing machine tools over time, has greatly increased technological competition. Another is the increasingly more sophisticated and specialised requirements of customers which is challenging the customised capabilities of machine tool manufacturers. Companies' most competitive strength is therefore the capability of making high quality and good performance machines with lower cost, as well as the ability to satisfy customers' specific requirements more effectively. As such, ITMT is well adopted and also seen as an effective way to improve the firm's technological capabilities so as to cope with the new challenge and competition.

The imports of foreign technology in China's machine tool sector have been increasing over decades. The total technology imports in the Chinese machinery industry (in which, machine tool is a major sector) were US$1.4 bn through 1980s (China Machinery Industrial Year Books, 1990), while in 1996 the total value of technology imports within the industry (including electronics sector) increased to US$2.33 bn, which accounted for over 15% of the total technology inflow in China. More significantly, technology software was 53% of the total imports of technology, while the average percentage of technology software import in the remaining sectors was around 10% (China Foreign Economic and Trade Year Book, 1997). As a result of technology imports, China's machine tool manufacturing capability is seen to have greatly improved. Taking CNC machine production as example, China was only able to make 24 models of NC machines in the 1970s, 175 models of NC and CNC at the end of the 1980s, but over 500 models of CNC machines by the mid 1990s (CMTBA, 1996).

1.1.3 Technology valuation: a critical issue in ITMT

Coupled with the rapid increase of ITMT there is, however, a question concerning the value of technology that arises in most technology transfer negotiations and collaboration arrangements (de Bruijn and Jia, 1993). The owner of technology would not like to lose its technological advantage if the gains from diffusing a technology are smaller than the expected returns (Aharoni, 1991). There have been many cases where multinational enterprises proved reluctant to conduct inter-firm transfers due to the value of technology not being fully appreciated by acquirers (Hymer, 1976; Teece, 1982). Acquirers on the other hand, regard the acquisition cost of technology as a prime criterion for the selection of a technology supplier (Glinow, Schnepp and Bhambri, 1991). The value of technology has become a critical question and it often causes time-consuming negotiations to establish an agreed value between the technology suppliers and acquirers. The value issue is seen as a major handicap to many transfer negotiations. It is even more often that suppliers and acquirers cannot reach an agreement due to the failure to establish a value of technology that is acceptable to both parties.

Suppliers may contend that acquirers do not appreciate the full benefits of transferred technology, while acquirers may argue that the value of technology cannot be determined until it has been proved in the market. It is evident that neither suppliers nor acquirers have an effective and acceptable means of establishing value. This may not only handicap the reaching of agreements but can also lead to 'ill-judged' arrangements with an unbalanced sharing of benefits, costs and risks, unfulfilled expectations and a possible breakdown of relationships.

Moreover, although both technology suppliers and acquirers have a willingness to share joint benefits through their collaborative operation, it is, however, not unusual that many collaborative ventures fail to produce expected benefits to satisfy both parties. Technology transfer potentially can generate benefits for both suppliers and acquirers but, at the same time, each party incurs costs and bears risks. Failed transfers are as common as successful ones, due to each side being inadequately equipped with information about the other side's motivations and expectations (Daniels, 1985; Davidson, 1987), or because of the shortfall of effective means of assessing the value of technology, or each side purely pursuing its own benefits while ignoring the inevitable impact on the other's share in the collaboration. This problem, in many cases, led to the consequence that the relationship stopped when the contract ended or, alternatively, each party had to reconsider its strategies and substantially modify its collaborative arrangements.

To summarise, there are two principal causes responsible for the above mentioned unsatisfactory results or failure:

i) the 'value' of the technology not having been adequately determined;
ii) the arrangements of technology transfer not having been properly judged.

1.2 Specific Background of The Research

1.2.1 The EPSRC (Engineering and Physical Sciences Research Council) project

In order to narrow the gaps with respect to the perceived value of technology between suppliers and acquirers, a framework of technology valuation is critically needed. Hence a research project, "Evaluation Models for Global Manufacturing: Technology Valuation", was undertaken under the EPSRC networking and globalisation initiative by the research team from Aston Business School. The project, which was initially planned to run for two years, focused on the valuation of technology being transferred from the UK to China. The overall aim of the project was to develop a technology valuation and collaboration model. The focus of the model was on how to achieve the best use of technology and efficient collaboration, which would assist companies in developing their technology transfer and global manufacturing strategies.

The project investigation was mainly conducted within the UK and Chinese machine tool industries, where British companies have a strategic interest in developing their overseas operations and there is a demand by Chinese companies to acquire technology. A number of cases were included from both UK and Chinese companies either engaged in technology transfer or intending to enter into such arrangements. The empirical data used to develop the framework were therefore gathered through the analysis of in-depth cases taken from different points along the value chain.

The research on which this thesis is based was a part of the EPSRC research project. The researcher was employed as the only full time contract research associate for the project. The major activities of the research associate, under the supervision of the two principal project investigators who are also the supervisors of this research (for a doctoral degree), included literature search, research investigation designs, establishing company links and organising visits, design and analysis of questionnaire survey and case studies, development of framework and contributions to the research output publications.

The main concerns of this thesis were to identify and measure the factors affecting the value of technology within technology suppliers' and acquirers' considerations (Zhao *et al*, 1998 and 1999). The research project, in addition, taking a broader view, extended to include the influences from related markets as well as the consideration of impacts from technology being re-sold by acquirers.

The thesis was a self-contained part although there was an element of team work in the research project. The thesis analysed data (gathered from the project investigations) and shared some of the basic value concepts and some identified factors with the broader project (Bennett *et al*, 1996a and 1997b). It commenced, however, with setting up and proving two research propositions as the breakthrough points, and used its own initiatives to conduct analysis in creative dimensions and to develop an original technology valuation and collaboration framework.

1.2.2 The previous study

The inspiration for doing this research arose from my initial study which was in the area of ITMT with a focus on the foreign and Chinese machine tool industries. The major concern of the initial study was the strategies of technology transfer into China's machine tool sector with an emphasis in the industry specifics. Through the study, some general issues, such as transfer strategies, forms of transfer and operations were identified, and some specific features related to the machine tool sector, such as, production differences and the technological position of China's machine tool industry in the world were also recognised. In particular, two questionnaire surveys[1] were conducted on the perceptions of foreign companies and the expectations of Chinese companies on transferring technology into China. The findings revealed the general views from both sides on the motivation for transferring technology, technological capability, as well as policies and obstacles related to the issue (Bennett *et al*, 1995, 1996b and 1997e; Zhao *et al*, 1996 and 1997). The findings from the surveys provided a comparable strategic concern with a more general view from both suppliers and acquirers and it consequently built up an initial body of knowledge for this more focused research.

1.3 Industry Focus: The Chinese and UK Machine Tool Industries

The research was designed to focus on a specific industry - the machine tool industry. By doing so the features of manufacturing technology and industry specifics, such as the characteristics of product, production, value chain and market, as well as factors related to technology transfer could be identified. This would enable the research question - how to value technology within the context of technology collaboration - to be explored explicitly so that the research objective could be achieved.

[1] These surveys were a part of the British Council project on "Industrial Development and Technology Transfer under China's Economic Policy Reforms" which was also carried out by a research team from Aston Business School. The researcher participated in the surveys by jointly designing the questionnaire and analysing the results.

Machine tools are used by all sectors of manufacturing and manufacturing technology is vital for the creation of all modern products, either directly or at some stages of the manufacturing process (Sciberras and Payne, 1985). Because no country could effectively and efficiently build every type of machine tool due to the vast variety of machines and sophistication of technology, international trade and production of machine tools are important to all nations. So the machine tool industry is typically heavily involved in international technology collaboration and, therefore, is one of the most ideal sectors for research where the issue of technology valuation are often raised.

This section briefly introduces the Chinese and UK machine tool industries in terms of their position in the world market, technological status, features of technology and production etc. The aim is to provide the industry-specifics in relation to the research issue.

1.3.1 The Chinese machine tool industry

1.3.1.1 Brief details of the industry, production and products

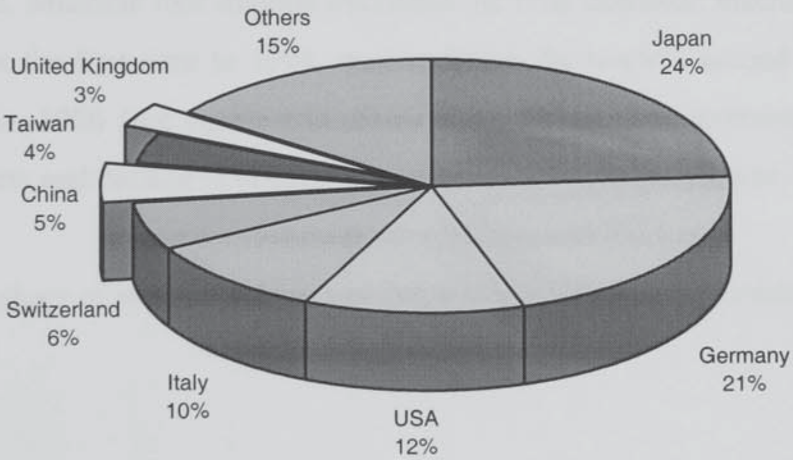
The machine tool industry is one of the conventional industries in China. The relatively high capital-intensive production has led to its development relying greatly on government support in terms of capital investment. Because of its longer history in the context of China's industrial development, it has achieved relative technological advantages in general when compared with many other sectors in China. In 1996, there were over 400 machine tool manufacturers with about 300,000 employees (CMTBA, 1996). The industry has however been restructuring since 1998 and some enterprises merged into groups. Currently around 200 enterprises/groups make metalcutting and metalforming machines and over 50% are manufacturing CNC machine tools according to the China Machine Tool and Tool Builders Association (CMTBA). Most of the machine tool enterprises are state-owned and are located in both coastal regions and inland areas. The industry has developed its own research institute networks with quite systematic focuses and divisions.

The range of products includes over 2500 models of metalcutting machines and 800 models of metalforming machines. CNC machines have been developed since the 1980s, mainly with the assistance of imported foreign technology. The annual production output is between 250,000 and 300,000 units and around US$1700 million in value (CMTBA, 1996). Production output of CNC machines reached over 9000 units in 1997, 13 times more than the output in 1980 (692 units) when China commenced CNC machine production.

1.3.1.2 The position in the world production

Along with the fast growth of globalised manufacturing over recent years, China's machine tool industry has maintained a rapid annual growth since the mid 1980s. Its current production capacity is one of the largest in the world in terms of annual output by volume. Its annual output value had doubled by the end of 1993 compared with 1985, making it among the world's top five machine tool industries in terms of output value. Since then, its annual output value has remained within the top eight in the world machine tool production (see Figure 1.1).

Figure 1.1 The share of world machine tool production output value among major countries in 1998 (Source: MTTA, 1999)



1.3.1.3 Technology gap

Despite the rapid development of CNC machine production in China, the substantial part of its annual output remains conventional types. The CNC machines only account for around 16% of annual total output value. Another feature is that the majority of CNC machines that China manufactured are 'economical versions' with simple specifications, low cost and limited functions. Through collaboration with foreign companies, China is also developing relatively sophisticated CNC machines such as multi-dimension machining centres, heavy-duty horizontal lathes and flexible transfer lines. Nevertheless, an obvious technology gap exists between the most advanced Chinese CNC machines and foreign CNC machines. In the research surveys, over 50% of the Chinese and UK machines tool companies assessed that the gap is of between 5-10 years and another quarter of the UK companies considered the gap to be more than 10 years. There is also a considerable gap in productivity between the Chinese and UK machines tool companies. According to the British Machine Tool and Technologies Association's statistics (MTTA, 1997), the average productivity in terms of annual machine tool output value per capita in China was US$5920 while in the UK was over US$82700, nearly 14 times greater.

1.3.1.4 Hyper-competition with foreign machines in domestic market

In recent years, domestic machine tool production has grown at around 16% per annum which led to a doubled annual output by both value and volume in 1993 compared with 1985. However, the inability of Chinese machine tool companies to build machines of sufficient quality and high functionality has also been recognised as a vital competitive weakness and it has resulted in a nine-fold increase of imports from the major industrialised countries during the same period. Machine tool imports exceeded the total domestic machine tool production output value for the first time in 1994, making China the world's second largest market for machine tools in 1996 (see figure 1.2). Since then the gap has increased with continuous growth of imports and decline of domestic production till 1997 (see Figure 1.3).

Figure 1.2 The share of world machine tool imports by value among major countries (Source: MTTA, 1997)

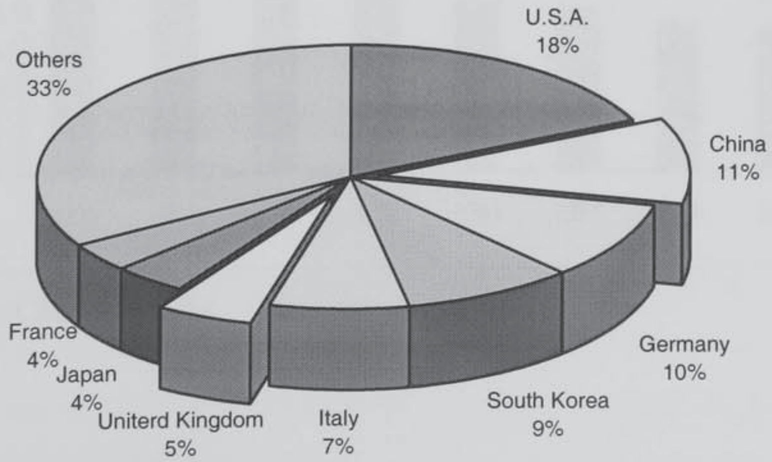
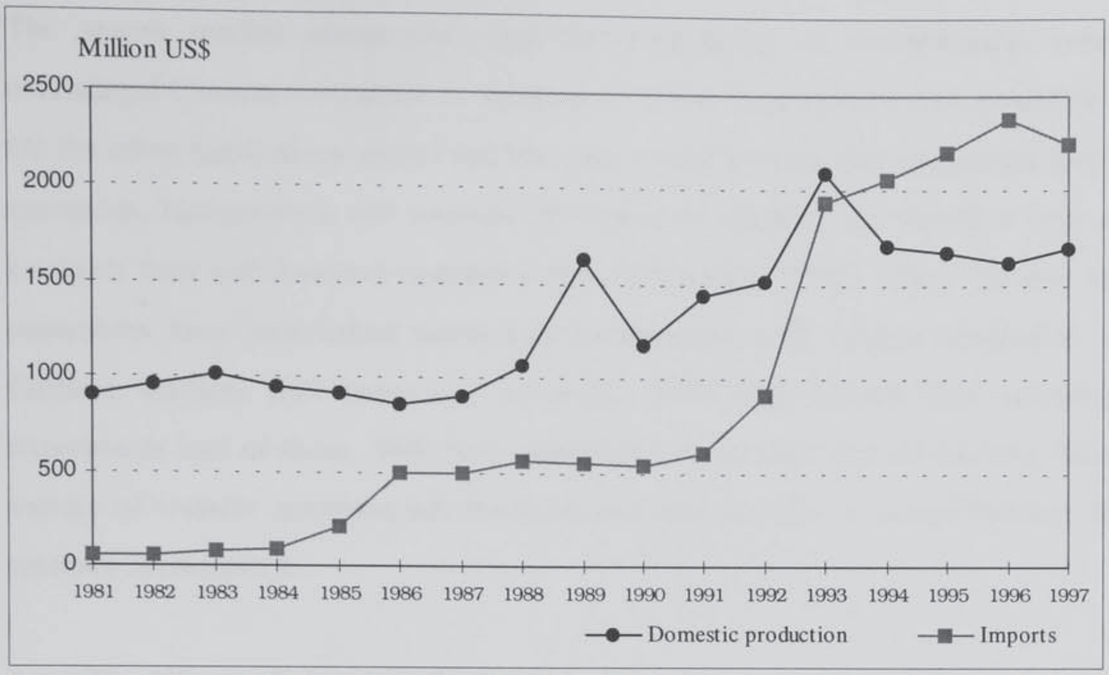


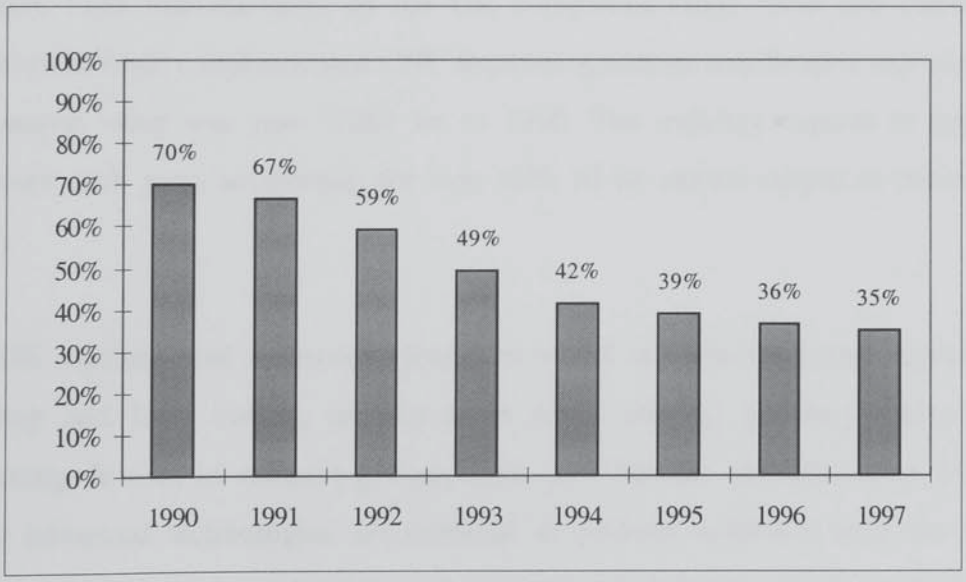
Figure 1.3 Machine tool production and import value in China since 1980s



Source: CMTBA, 1998

As a result, Chinese-made machines have lost a considerable share of the domestic market. Its market share dropped from 70% in 1990 down to 35% in 1997 (see Figure 1.4).

Figure 1.4 Domestic market share of Chinese machine tools by value in 1990s



Source: CMTBA, 1998

1.3.1.5 Technology transfer activities

The severe market competition and the recognition of technological weakness have encouraged Chinese companies to make more efforts to acquire foreign advanced technology. On the other hand, many global machine tool manufacturers also recognised that China is an enormous, fast-growing and strategically important market, and therefore they are eager to establish their collaborative operations there (Pinkham, 1999). Many Chinese machine tool companies have established technology partnerships with foreign companies. Among the Chinese machine tool companies surveyed, 85% have already had technology transfer experiences and of these, 36% have undertaken more than one transaction. There is also a variety of transfer arrangements involved and this provides a comprehensive basis for the research investigation.

1.3.2 The UK machine tool industry

1.3.2.1 Brief details of the industry, production, products and technology

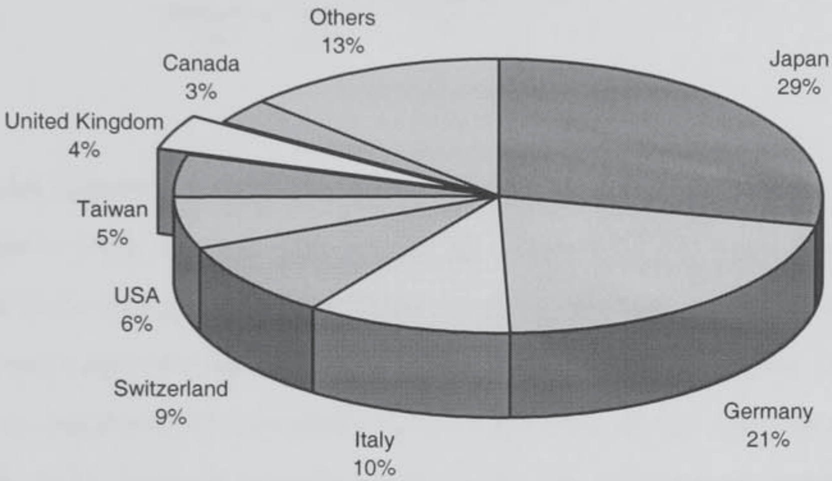
Machine tool companies in the UK are located all over the country, but particularly in West Yorkshire, and the West and East Midlands. There are about 120 machine tool and equipment manufacturers in the UK and the average number of employees is around 14000 in the sector. Machine tools manufactured by the UK companies range from conventional, stand-alone machines to highly sophisticated CNC machining centres and flexible manufacturing systems. The output value was near US$1 bn in 1996. The industry exports to approximately 150 countries each year, accounting for over 60% of its annual output in recent years (MTTA, 1997).

The UK machine tool technology leads the world in some important aspects. For example: grinding and laser cutting techniques in metal cutting; probes, sensors and coordinate measuring devices in measuring equipment; and flexible manufacturing systems in design. These advanced technologies are essential to provide machines with the features of high processing productivity, reliability and production flexibility. As far as the UK machine tool export is concerned, machining centres is one of the key strengths, which generated a significant trade surplus in this particular category of equipment according to the MTTA statistics (MTTA, 1999).

1.3.2.2 The position in the world market

The UK machine tool sector is relatively small compared with other major machine tool producing countries such as Japan, Germany and the USA. Nevertheless, its production output and also import and export value are all among the top 8 places in the world. (see Figures 1.1, 1.2 and 1.5).

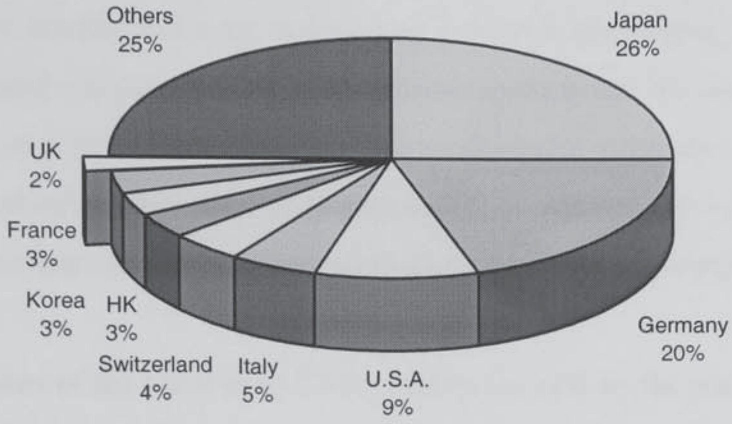
Figure 1.5 The share of world machine tool exports by value among major countries in 1998 (Source: MTTA, 1999)



1.3.2.3 Business development in China

Although the trade of machine tool products between the UK and China started in the early 1970s, the business development in China was slow and has lagged behind some other major machine tool producers such as Japan, Germany and USA in particular. China was between the 3rd - 9th largest UK machine tools' export market since 1993 (except for 1997) but still only accounts for between 3-8% of the UK machine tool industry's total annual exports (MTTA, 1997 and 1999). Although China has become the second or third largest machine tool importer since 1993, the UK machine tool exports to China only account for less than 3% of China's total machine tool imports (see figure 1.6).

Figure 1.6 The share of China's machine tool imports by value among major countries (Source: CMTBA, 1996)



The machines exported to the Chinese market and technology transferred to Chinese machine tool companies from the UK were almost all advanced CNC types since the middle of the 1980s. Due to the fast growth of the Chinese market for machine tools it has been focused as a major targeted market by the UK machine tool industry in recent years. Most of the major UK or UK based machine tool companies have established, or are going to establish, technology partnerships with Chinese manufacturers. With UK government support the MTTA also opened its office in Beijing in 1995 to promote machine tool exporting to, as well as manufacturing in, China (MTTA, 1996b).

1.3.3 The relevance of the UK and China machine tool industries to the research question

Despite the output of machine tool sectors accounting for only a small part of the economies in both UK and China, they are both among the first eight major machine tool players in the world in terms of production output, import value (the UK machine tool sector is also in the top eight by export value) in recent years. More importantly, experiences of transferring technology with various forms/arrangements have been gained by companies in both sectors and increasing enthusiasm for further collaboration is being shown. The varieties of practice provide many cases with distinct features which has allowed this research to gain rich insights from investigations.

Although believing that transferred technology would improve the quality and performance of Chinese machines so that future benefits can be generated, disputes on the value of technology often arise between technology suppliers and acquirers. Both Chinese and UK machine tool companies have already had such experiences in which the context of technology valuation may not have been adequately understood and the arrangement for sharing future value, costs and risks may not have been considered in conjunction with the best use of technology through the collaborations. The establishment of a technology valuation framework has become an important issue to improve the effectiveness of collaboration in the sector.

The investigations of the research in China mainly focused on the period from the mid 1980s, a few years after China carried out its economic reform, to the present. This is because, before that time, the main flow of foreign technology imports in Chinese machine tool industry was organised and sponsored financially by the government, and also, a substantial part of these technologies was imported through one-off transactions. The value of technology, as well as the impact of collaboration was not necessarily considered by the state-owned companies under such a situation, although the effects of transfer were in question. The value issue was not realised until the middle of the 1980s, when the decision power and responsibility were given to enterprises, and when technology transfer through on-going collaborations became increasingly more adopted.

The research exploration for the technology transfer activities from UK machine tool companies to China also focused on the same period as it did in China. It was then that technology transfer partnership between the UK and Chinese machine tool companies started to increase. Consequently the issue of technology valuation and collaboration was encountered and its importance was gradually being realised.

1.4 The Research Context: Differences in Perceptions of Value Between Suppliers and Acquirers

The gaps between the suppliers' and acquirers' perceptions concerning the value of technology are not simple misunderstandings. There are a number of factors which make it difficult to determine an agreed value of technology. There can also be many reasons why the acquirer's perceptions of the value could be lower than that of the suppliers. The project investigation revealed the related factors which may explain the differences in the perceptions of value between the suppliers and acquirers. The following factors in general highlight the causes which make it difficult to determine a value for technology to be acceptable both to the supplier and acquirer. These factors form the research context within which the investigations further focus more on the assessment of the impacts from specific factors on the technology valuation.

1.4.1 Differences in the perceived strategic and commercial importance

The importance of technology to suppliers and acquirers in terms of their respective potential is one of the strongest influences on the value placed on that technology. The differences in relative importance of the reasons for transferring technology provided an indication of the strategic and commercial worth of foreign technology to both suppliers and acquirers (Bennett *et al*, 1997a and 1997e; Zhao *et al*, 1997). It can be implied that if the technology is capable of meeting the first priority motive then the worth of the technology is likely to be considered higher than if it could only satisfy a less important reason. Any restrictions on the use of the technology could therefore reduce its value to the acquirer.

1.4.2 Differences in perception concerning the technology gap

The CNC machines had reached 50% of the total value of machine tool production in DCs such as Japan and the USA by the mid 1980s, while in China the share of CNC machines only stood for 16% of the total value in 1997 (CMTBA, 1998). More specifically, China's machine tool sector currently has the ability to produce many types of CNC machines (over 500 models according to CMTAB) at lower cost but with poorer quality and reliability than those of the major industrialised countries. However, the project investigation found that the size of the gap between foreign and domestic technologies was evaluated differently by foreign suppliers and Chinese acquirers, with larger gaps by the former's assessment than the latter's. The suppliers' perceptions of the technology gap have been recognised to have an impact on the technology to be transferred in terms of technological level, for example, high-tech or lower-tech content know-how (Young and Lan, 1997), which in turn would lead to a difference in perceptions on the value of technology.

1.4.3 Differences in the form of collaboration

While some technology embodied in hardware and even some software in the form of expertise can be readily bought and sold in the market, this is not true in all cases. The value of technology cannot be considered in isolation from the actual types of technology transfer arrangement which could range from one-off transactions of selling a complete turnkey equipment to technology based equity joint ventures. There are some cases, on the one hand, where the acquirers were required to pay the full price of the technology up-front, while on the other hand, technology was offered to the acquirers initially free of charge. The value of technology is seen to be affected by the types of arrangements as well as the specifics of agreements (Bennett *et al*, 1998a, 1998c and 1999c).

1.4.4 Differences in perception of product standard

Foreign-made machine tools are normally made to the international standards of quality, reliability, performance and safety, while Chinese-made machines have different standards or requirements. For example, machines built in the UK must, by law, meet the CE standard (European Safety Standard) which has much more comprehensive measures to guarantee the safety than the Chinese standard. In the CE standard, the measures for eliminating hazards include inherently safe design (e.g. two-hand control device, emergency stop devices, and safety distance to prevent danger zones etc.), additional protection devices (e.g. interlock device associated with guards, proximity switch with fault prevention and pressure sensitive safety device etc.) and personal protective equipment and/or training. While by the Chinese standard the machine design includes fewer safety measures and the additional protection devices may not even be considered. Hence the costs reflecting the safety elements which are beyond Chinese standard may not be fully appreciated when the value is judged by the acquirers (Bennett *et al*, 1998b).

1.4.5 Differences in machine tool production

For a Chinese machine tool, most of the parts and components are made in-house by the machine tool manufacturers themselves. This is because the low level of industry integration hence there are not many qualified and efficient local suppliers of components. By contrast, foreign machine tool companies have a large percentage of parts made by subcontractors. The difference can affect the acquirers' perception of value in two aspects: (a) acquirers would consider that technology provided by foreign machine tool companies only covers part of production (i.e. assembly and machining of some key parts) and (b) local parts being made without foreign advanced technology support may not be able to reach a high quality standard therefore would affect the reliability of the end products (complete machines). Consequently, the value of technology may not be as much recognised and appreciated as suppliers by the acquirers (Bennett *et al*, 1998b).

These differences make it difficult to establish the value of technology that both suppliers and acquirers can accept. However, many suppliers and acquirers do not seem to be fully aware of the complexity and the important implications behind the differences of the value in their perceptions. The issue was often perceived by both parties in a way that 'value' was regarded as 'price', and 'valuing' technology was simplified as 'pricing' technology, or a matter of cost assessment. As a result, it is not unusual that technology is claimed to be over-valued by one party but regarded as under-valued by the other after technology has been transferred (Bennett *et al*, 1997c).

1.5 The Focus of The Research: Technology Valuation and Collaboration

Overall, the valuation of technology is seen as a critical issue in technology transfer negotiations and the form of any final agreement. The value of technology that is established may reflect the relatively different positions including strategies, perceptions, technology gaps, and forms of collaboration between suppliers and acquirers.

The research question is then how to value the technology within the context of technology transfer arrangements. The objectives of this study are: (a) to gain an improved understanding of the nature of value of technology and the core of technology valuation; (b) to establish relationships between factors/aspects affecting value and valuation process; and, on this basis, (c) to develop a conceptual framework for mutually acceptable solutions towards an achievement of the best value generation and realisation.

To study this critical issue, the research started with identifying and analysing the extent to which the key factors affect the value of technology. It follows that the research goes further to assess and measure the impacts on the value of technology from the objectives for technology transfer, the contributory factors that influence transfer result, technology attributes that can be transferred and absorbed, and sharing arrangement of benefits, costs and risks associated with transfer in the specific collaboration arrangements. The value of technology to be measured and established from three value dimensions is developed so that it can be accepted by both suppliers and acquirers with consideration of gains and losses in financial, technical and strategic aspects.

The related issues are discussed in the order as follows: this chapter has introduced the issue of technology valuation in the context of technology transfer, the research background, industry focus and research concerns. Chapter 2 contains a review of literature including related theories and discussions. Chapter 3 explains the research methodology comprising research hypotheses, research design, and methods employed for the investigation and analysis. Chapter 4 analyses the owner's value with identification of its major elements as well as factors which may have impacts on it, and measures the impacts on the owner's value from the technology supplier's point of view. Chapter 5 is a parallel assessment to Chapter 4 but focuses on the transfer value with considerations from technology acquirers. Chapter 6 assesses the features of forms of technology transfer and sharing arrangements for benefits, cost, and risks, and their significance in valuing technology. Chapter 7 demonstrates the results of case studies locating technology valuation within the context of technology collaboration and analyses the impacts of specific technology arrangements on the value determination. Chapter 8 incorporates commercial, technical and strategic considerations into technology collaboration arrangements, establishes three value dimensions for valuing technology and develops a framework for technology valuation and collaboration. Chapter 9 provides the conclusions from all the above assessments.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter introduces the related theories of international technology transfer (ITT) linked to the issue of technology valuation. The overall review was carried out in three dimensions: ITT theories related to the issue of technology valuation; valuation approaches, and ITT situations/factors related to the value issue in China.

The first dimension (ITT) of the review sets out to build up a fundamental basis for technology valuation. As ITT is a broad area and the relevant theories are very extensive, a thematic classification is primarily required to provide focus in the literature review. The main issues pertaining to technology valuation under the context of ITT were adopted as a filter in the selection of relevant theories. The theoretical considerations include: what is the core of technology to a firm; why do firms need to transfer technology; and how the value issue affect the transfer strategy? These theoretical perspectives provide an explanation of why technology transfer is taken as an important strategy rather than an alternative operation, and furthermore, imply that technology valuation cannot be isolated from the objective of technology transfer - the best use of technology to enhance the competitive advantages. The following specific perspectives are explored:

- The definition of technology and contents of transfer
- The nature of technology and the fundamental objective of technology transfer
- Transfer strategies with concerns of value of technology
- The theoretical development and limitation of the value issue in the context of ITT

Further to the presentation of the related ITT theories, the literature review approaches the more focused aspect - product/technology valuation in the second dimension. The main body of knowledge in this dimension has not been established under the context of ITT. It however still provides some useful theoretical implications and techniques for the subject of this enquiry. Finally, the main issues linked to technology valuation within the context of ITT in

China are discussed which provide more detailed factors by which technology valuation is affected in specific situations.

The limitation of the existing theoretical approaches to the value issue in the ITT context is found and hence it calls for further investigation in broad dimensions. The chapter however concludes with a consideration of the implication of the main body of knowledge for this study and issues of interest, which will be carried out for investigation in the fieldwork.

2.2 Theoretical Perspectives of International Technology Transfer Related to Technology Valuation

2.2.1. The definition of technology and the contents of transfer

It is a controversial area between technology suppliers and acquirers in terms of technology, the contents to be transferred and hence its value. The controversy over the issue occurs where the parties are using different definitions and are not aware that others have a different concept in mind. It is therefore necessary to have a clear definition of technology before further discussions.

Technology is distinguished from science in that science "organises and explains data and observations by means of theoretical relationships...technology translates scientific and empirical relationships into practical use." (Hall and Johnson, 1970). A more detailed and comprehensive definition of technology was given as “technology is a perishable resource comprising knowledge, skills, and the means for using and controlling factors of production for the purpose of producing, delivering to users, and maintaining goods and service for which there is an economic and/or social demand.” (Stefan and Robock, 1980).

The definition recognises the importance of knowledge, skills, and other means not only in production but also in terms of delivery and maintaining products (Conners, Samli and Kaynak, 1985). The capacity both to maintain existing technology and to create new technology are included. It implies that technology should comprise *effectiveness* of know-how and skill as well as the capability of *effective use* of the knowledge.

Given the definition of technology, the following classifications of technology help to identify, in more details, the scope and extent to which technology may be transferred. These groupings of technology are presented as dichotomous classes:

(i) Hard technology and Soft technology.

Hard technology refers to the equipment that often requires accompanying soft technology. It is particularly true for industrial products such as machine tools that some design and operational knowledge for the efficient utilisation of such hardware are embodied. *Soft technology* refers to drawings/blueprints, technical specifications, product development and process programming know-how and skills, computer programs (e.g. CNC control system), management and marketing techniques.

Hard and soft technology, to some extent, referring to product (specifying its characteristics and uses) and process technology (how a specific product is produced) (Baranson, 1970), firstly need to be distinguished due to their different implications for the extent to which the technology can be used (Germidis, 1977). In the machine tool sector, product and process technology are almost always combined together because many design and operational features are embodied into the functionality and performance of the machines. Hence it is necessary to assess both elements to judge the *product* implication for future market and the *process* contribution to technological capability development, by both suppliers and acquirers.

(ii) Proprietary technology and Non-proprietary technology.

Proprietary technology refers to the knowledge that is owned or controlled by a particular company or organisation (the owner). It may be held as a trade secret, or it may be published as a patent. *Non-proprietary technology* includes knowledge contained in technical literature, hardware, and services that can be imitated or reproduced by observation and through reverse engineering without infringement of the proprietary rights (reverse engineering simply means to learn how to reproduce equipment by taking it apart).

Proprietary technology and non-proprietary technology have been seen to be a cause of debate on the commercial value of technology. On the one hand, the owners of technology argue that proprietary technology which was developed with a high R&D investment should have a high commercial value (Frank, 1980). On the other hand, acquirers are concerned that, being generally protected by a patent, monopoly proprietary technology inherently permits the technology supplier to extract an excessive monopoly price (Lall, 1984), and also argue that technology development costs have been already amortised over previous market sales. Consequently, international transfers need not be compensated at much more than the incremental cost of the transfer.

(iii) Bundled technology and Unbundled technology

Bundled technology refers to controlled technology that the owner is willing to transfer only as part of a package, generally including an ownership interest in the foreign affiliate or collaborative partner using the technology. *Unbundled technology* is made available independent of the technology supplier's total package of resources.

Bundled technology and unbundled technology is a frequently occurring issue in connection with the flow of transferred technology or systematic transfers in the process of ITT. Chantramonklasri (1986) submits that in principle, technology transfer agreements may include two broad flows of technology: first, improvement of production capacity; and second, technological capacity which includes system-related knowledge incorporated within the production system (transferred), such as knowledge about the basic principles and characteristics of the manufacturing process, technical and managerial knowledge and skills. Vyas and Shah (1990) and Cusumano and Elenkov (1994) propose a systematic transfer in that technology transfer should be treated as a composite system: (a) product transfer with underlying part of knowledge disclosed; (b) product design transfer and (c) capacity transfer with the whole technique and expertise to manufacture the product. In a broader view, transfer should include "the knowledge of getting things done" (Lan, 1995 and 1996).

Although, as Porter (1985) suggests, the likelihood of other firms with competing technologies entering the market, and barriers against entry into markets for the products of the technology, can sway the balance in favour of transferring technology instead of retaining it within the firm (supplier), the transfer of key (proprietary) know-how and/or the transfer of complete (systematic) knowledge have still remained as a concern of the suppliers (Salami and Reavill, 1995). Lan (1996) suggests the value of technology transferred to China is low due to the technology mainly being involved in low value-added activities. This may, to certain extent, reflect the owner's desire to maintain control over key proprietary knowledge

(Malecki, 1991). Recently, there were more debates on the issue of partial or incomplete technology transfer from DCs to LDCs (Young and Lan, 1997), and acquirers often claimed that key know-how and complete technology were not transferred (Bennett *et al*, 1996a; Martin, 1995).

2.2.2. The nature of technology and the fundamental objective of ITT

From the concerns of what is to be transferred, a question is raised of what would be the fundamental objective of ITT or why a firm needs to transfer technology? On the one hand, Porter (1985) raises the suppliers' concern, that making technology available to another firm (acquirer) could lead to the possible loss of the competitive advantage embodied in the technology. On the other hand, Goldenberg (1988) and Teece (1987) put forward the argument that technology transfer is an effective means for the owner to maximise the benefits through an international collaborative operation by developing access to an expanding market as well as exploiting local advantages.

The core issue behind technology transfer is therefore whether or not the advantage can be enhanced. The following theoretical discussions concerning the exploitation of *advantages* shed light on the overwhelming objective of the ITT activities. Technology can only be meaningfully transferred when effective use and enhancement of the advantages are achieved.

2.2.2.1 Technology affects competitive advantages

Competitive advantage is a generic concept without specifying the means hence was established as the general terms to judge a firm's strength and position in markets. (Porter, 1980 and 1985). In the assessment of key factors in determining the competitive advantage, Porter (1979 and 1985) argues that resource/basic factors do not constitute an advantage in knowledge-intensive production. It is because of that the competitive advantage is created but not inherited. Technology is the key to highlight the critical strength or weakness of a company and it has been evident as the primary force to create competitive advantage dynamically. Companies achieve competitive advantage through acts of innovation which including both new technologies and ways of doing things (Porter, 1990).

The key role that technology plays in affecting firm competitive advantages was further discussed in the context of a value chain. Porter (1985) argues that competitive advantage stems from many discrete activities and suggests that linking all the value activities by using the value chain concept would provide a basic tool for a firm to diagnose its competitive advantage and to enhance it by performing these strategically important activities more cheaply and better than its competitors. On this basis, Dicken (1992) points out that technology is an enabling agent which makes a new structure, thus technology change may also restructure a value chain. Betz (1993) further notes that such restructuring may be arrived by: (a) altering vertical integration in a value chain; (b) creating new product-line variations in a segment of value chain; (c) making product lines obsolete in a segment of value chain; (d) providing substitution-technology products in a segment of value chain.

Porter (1985) subsequently proposes that a firm's value chain is embodied in a large stream of activity, known as 'value system', which demonstrates the 'tied-up' relationship of all the value actives within the value system. Within the system, technology changes upstream may affect the downstream significantly: (a) lower cost may move applications into low-priced market niches; (b) improvement of quality and performance may bring, or increase, substitutions into current applications and (c) the simultaneous improvement of cost, quality, and performance may move applications into new market niches etc. Moreover, the impacts from technical changes may cross industrial sectors which reflects in the 'industrial-sectors economic value chain' as a consequence of the transformations. As the increase of the inter-industry flow of technology (Hanel, 1994), Betz (1993) notes that technology changes may fuse two different industrial value chains together, in other words, the technological convergence leads to unrelated industries becoming related (Capon and Glazer, 1987), or make obsolete an entire industrial value chain with a substitution value chain. The competitive conditions of firms would therefore be directly affected by technology changes within an industrial sector as well as indirectly from other sectors. This is particularly significant for the sectors whose products consist of major components produced by other sectors. For example, the changes in electronics technology has in fact led to a fundamental substitution of conventional machine tools by CNC types in the machine tool sector (Sciberras and Payne, 1985 and 1986). Technology changes in other industries may also result in inadequacy of a firm's currently used technology, therefore requiring structural changes. For example, the emergence of new materials in manufacturing aircraft, such as weight-reducing composite materials, or in producing automobile engines, such as ceramics, requires radically different technology in machining and forming which would involve machine tool manufacturers in technological and skill reorientation and changes (Sciberras and Payne, 1985).

2.2.2.2. Exploiting/improving competitive advantages through ITT

Given the core of technology as the superior capability which would provide specific advantages to the owner (Dunning, 1993), Aharoni (1991) argues that a firm gains a crucial competitive edge through technological advantage only if it can exploit this advantage. The question is how the capability/advantage is effectively exploited and enhanced. Further to this question, the recognition of a firm's competitive advantages within the context of the value chain system provides a guide to the firm's activities which should focus on its core competence, but meanwhile it should also effectively use the external resources (Kodama, 1992; Porter, 1986 and 1990). Instead of a 'change driven' reaction (Holt, 1990), the identification of competitive advantages in value chains enables a firm to locate its critical success factors and to keep them as the competitive focus (Kogut, 1991). Porter (1990) suggests that the idea is to deploy the limited resources into the most productive uses by means of technology transfer. In this regard, Teece (1986a) argues that ITT also reflects the firm's desire to integrate different stages of the value chain so as to capture the advantage of economies of scope by the use of complementary assets. As a result, "the transfer of skills involves activities important to competitive advantage" for both supplying and receiving parties (Porter, 1990).

For exploiting competitive advantages by means of ITT, Kindleberger's exposition (1969) more specifically examined the main areas where internationally transferable advantages can be derived.

(a) Departure from perfect competition in product markets such as product differentiation and marketing skills; and

(b) Departure from perfect competition in factor markets such as access to patented or proprietary knowledge and capital, differences embodied in the firm as managerial skills; and internal and external economies of scale such as vertical integration.

According to Kindleberger's model, an MNE must possess an internally transferable advantage which gives it a quasi-monopolistic opportunity to enter a host-country market. Kojima (1978 and 1982) made a special contribution to embracing intermediate factors (e.g. technology and managerial skills etc.) into cross-border transactions.

The theory of the eclectic paradigm (Dunning, 1976) subsequently explicitly identified three types of firm advantages and argues that MNEs will engage in international activities on the basis of these advantages:

(i) Ownership-specific advantage that enables a particular firm to expand. It refers to the property of certain intangible assets, such as technological and managerial know-how, innovatory capacity, and the presence of particular organisational and marketing systems etc. that give the firm competitive advantage.

(ii) Internalisation advantage that decides the expansion is best accomplished within the firm rather than by selling and/or leasing the rights to the means of expansion to other firms. The advantages can derive from control over suppliers or market outlets, yields of economies from interdependent activities and better protection of product quality etc.

(iii) Localisation-specific advantage that determines whether expansion is best achieved at home or abroad. Such advantages are typically more attractive inputs in terms of cost, quality or productivity. Costs of international transportation, communication and market information also fall in this category.

Dunning (1979 and 1993) further explains that all the three specific advantages are interrelated. A firm with certain ownership advantages over its competitors is the necessary prerequisite to exploit its advantages through ITT. The internalisation advantage enables an MNE to expand its ownership advantages within the firm with best results. (A notable implication from here is this ability may extend to establishing collaborations if it is more effective than intra-firm transfers). The location advantage refers to the better access to local contacts and/or resources that firms are able to acquire which helps to internalise intermediate product market better than another. Hence, when appropriate, MNEs would expand their operation by establishing new production sites in the places where localisation advantages are particularly attractive and can thus reinforce their ownership-specific advantages.

The means to exploit the firm-specific advantages, as the MNEs theories initially focused, were however on the intra-firm technology transfer. Buckley (1983) theoretically challenged the concept of firm-specific advantages by arguing that they should be reflected in a dynamic process. The existence of firm specific advantages depends on a set of assertions on: (a) the diffusion of technical and marketing know-how; (b) the comparative advantage of firms in particular locations; and (c) the existence of particular types of economies of scale. Thus, firm-specific advantages are not confined to the endowments of proprietary knowledge within the firm but also the abilities to determine its expansion paths faced with the dynamic reformulation of industry barriers to entry, and to exploit the technological advantages in the right locations and with the appropriate forms of collaboration.

The above theoretical discussions recognise that technology is a key element of the competitive advantages and the important contributions that ITT makes to the enhancement of the firm's advantages. The enhancement is derived from exploiting the complementary advantages that each party possess hence the joint strength would be significantly greater. To integrate production on a more competitive basis, and to combine complementary advantages globally, ITT has acted as one of the most effective links to capitalise firm advantages so that a greater return can be achieved. These literature provides a significant implication for technology valuation that both suppliers and acquirers need to fully recognise that the joint advantage can only be derived from their technology collaboration and when they assess the value of technology, they are not assessing a specific product, but an enhanced capability or competitive strength.

2.2.3 Transfer strategies with concerns of the value of technology

Further to the discussions on the importance of ITT in enhancing firms' competitive advantages, an immediate question is raised of how to transfer technology so as to exploit the advantages more effectively. As Porter (1990) argues that a firm's competitiveness derives from how it performs on a world basis, the primary principle of the ITT strategy is, as Dunning (1976) and Buckley and Pearce (1979) put, that firms will engage in foreign investment whenever they perceive that it is best to combine their competitive transferable intermediate products (technology) with immobile factor endowments or other intermediate products elsewhere where there is a local advantage or complementary assets. However, in practice, the determination of transfer strategies was not without the influence from considerations of the value of technology, by the means of cost and price implicitly. This concern has been particularly revealed in the MNEs' preference for the internalised technology transfer (to wholly-owned subsidiaries) over the external collaborations (e.g. Buckley and Casson, 1976 and 1988; Hymer, 1976).

2.2.3.1 Wholly-owned subsidiary

The form of wholly-owned subsidiary was initiated from the firm theory conceived by Coase (1937). The theory holds that the firm and market are the only alternative methods of organising technology exchange. The choice between intra-firm (i.e. wholly-owned subsidiary) and market exchange (i.e. inter-firm such as JV and contract based technology collaborations) is based on their relative cost. Arrow (1962) argues, and many studies (e.g. Casson, 1979; Dunning, 1981b; Magee, 1977) cited that market exchange of technology would be more costly than intra-firm transfer. This view focuses on the failure of the market to facilitate the transaction of certain types of resources and transfer costs can be significant as a result of such market imperfections (Davies, 1977). This insight has been further investigated concerning different types of technologies by Davidson and Mcfetridge (1990). Their study discovered that technologies with the following features may require more costs to deliver: (a) newer technology; (b) technology which presents more significant advance of state of the art and (c) technology with fewer substitutes. It incurs higher cost to measure the quality of products and service associated with such technologies when external transfer is taken place (Williamson, 1979 and 1982). This implies that there is a difficulty to measure the worth of transferred technology and further concern from it is whether the worth can be appreciated by the technology recipients.

More specifically, Hymer (1976) argues that the advantage-possessor cannot appropriate the full return from its external utilisation. Killing (1980) and Howells (1996) assess that this was because knowledge is often 'tacit' and 'uncodable' hence affect the transferability. Casson (1987) further argues that this was also because the market for knowledge is imperfect including technology suppliers' uncertainty about the property rights protection in foreign countries and technology acquirers' uncertainty about the quality of the end-product because the technology is indivisible. This refers to Teece's explanation (1982) that despite the suppliers' assertion of the quality of end-product, the know-how cannot be fully divulged to the acquirers because, by providing such a 'proof', the value of the know-how may be partly devalued.

The transaction cost perspective is one of the major theoretical approaches in transfer strategies. It suggests that firms' growth often cannot be achieved by selling or leasing out the excess capacity to other firms but requires an expansion of the boundaries of the firm (Williamson, 1985). As a result, the firm has to engage in acquisitions of other firms in order to achieve such growth through 'internalisation'.

Barney (1986) therefore suggests that, under perfect conditions, firms do not sell their technologies if the full value of such strategic resources is not reflected in the price. On the other hand, technology acquirers may be unwilling to agree a price unless the nature of technology is revealed to them. Jensen and Ruback (1983) hence argue that there must be efficient strategic factor markets such as financial markets so that firm ownership and associated property rights can be smoothly transferred. The remaining problems of technology valuation explain the prominent position regarding FDI as the major vehicle of ITT by many MNEs (Rugman, 1981 and 1986; Teece, 1976, 1981 and 1986b).

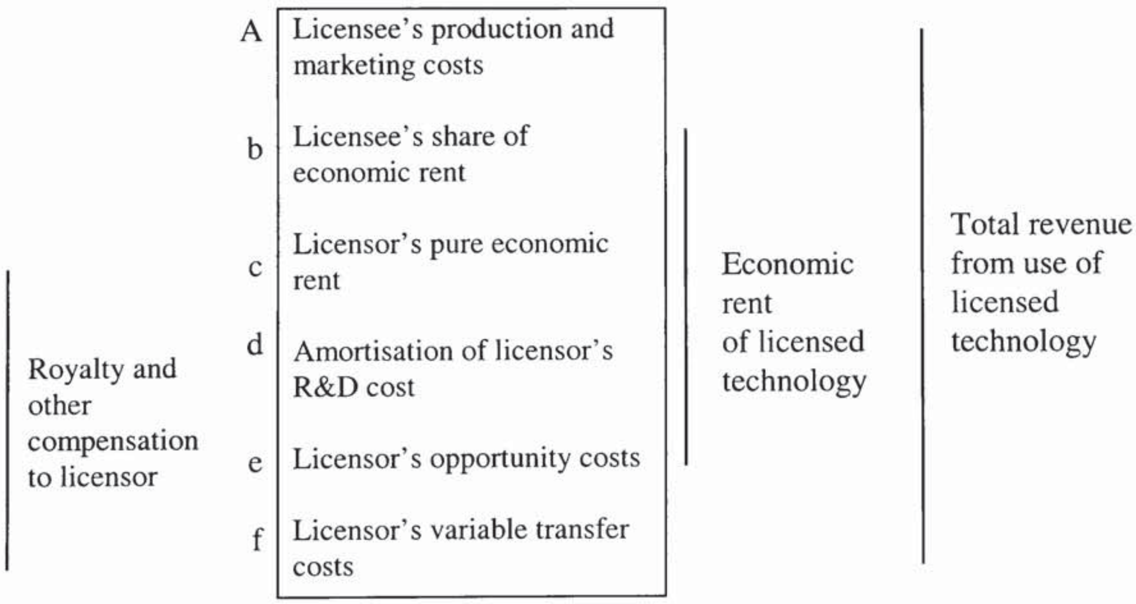
2.2.3.2 Contractual technology collaboration

Hennart (1988), Teece (1988) and Pisano (1990) reveal that, in determining whether to exploit, lease, or sell its ownership-specific endowments (technology), a firm's interests always focus on who, itself or the acquired firm, can use these assets better. It raised a further question of how to judge the benefits extracted from external transfers not only by the firm but also the acquirer.

In the traditional view of licensing (e.g. Buckley and Casson, 1976; Dunning, 1981a; Tang and Yu, 1990), it is argued that the net profits extracted by the licensor from a external licensing transaction are lower than keeping the technology in-house or licensing it to the firm's own subsidiaries. This is not only because of the higher transfer cost due to the licensee's technological inferiority and unfamiliarity with technical standard and procedures, but also because the full return from transferring technology to other firms may not be gained. However, there was a rather heated debate over this issue. Rapp and Rosek (1990) argue that acquirers from LDCs complain an unfairly high price for the technology from licensing. Too high a proportion in the form of license fees and royalties were extracted from the revenue derived from licensing by the suppliers (UNCTAD, 1987).

Root's and Contractor's study (1981) submits that the revenue from licensing should be allocated to the both parties to cover their respective costs as well as to add to their respective economic rents. The economic rent of the licensing agreement refers to the licensee's total revenue from the use of the licensed technology minus the sum of the licensee's production and marketing costs and licensor's transfer costs (i.e. b + c + d + e, see Figure 2.1). The licensor's compensation was however allocated to three types of costs before the pure rent accruing to the licensor.

Figure 2.1 Allocation of licensee's revenues from the sales of the product using licensed technology



Source: Root and Contractor 1981, pp.24.

In this model, costs were seen as causing a major debate. On the one hand, Frank (1980) puts that the owners of technology believe that the sale of present technology should not only cover sunk costs but also provide revenue to fund future R&D. Hence, technology which was developed with high R&D investment should comprise a high commercial value. In addition, amortisation of costs of failed R&D efforts may also be included in the compensation derived from licensing (Contractor, 1985b). On the other hand, Perlmutter and Sagafi-nejad (1981) and Lall (1984) argue that, from the acquirers' point of view, technology development costs should not be included in the cost of ITT because the local markets were not the prime motive for the initial development of the technology. Chen (1996) adds that the opportunity cost is thought highly hypothetical and is not properly understood by licensees, hence they are reluctant to recognised this cost as legitimate, at least at the level of the licensor's estimation. Furthermore, Aharoni (1991) argues that, to acquirers, in most of cases the costs of licensing fees are minuscule compared with the total costs of overcoming technological barriers (e.g. heavy duty for imported parts) and making the technology work. This is because there are many costs that are usually not recorded as cost of transfer (e.g. cost of long period of under-utilisation of equipment during the process of transfer or delay in supply of components and in commencing production).

Another argument focuses on the extraction of returns. Contractor (1985b) notes that the licensor attempts to restrict the licensee's share of local revenue to a normal return on investment and maximise its own profit. But the licensee tends to place a lower value on the technology so as to provide license fees below the repatriable profit that they may earn by an equity investment.

The third argument is that under the protection of a patent, proprietary technology inherently allows the technology owner to extract a high price (Lall, 1984). However, Leff (1979) suggests that such a price premium is influenced by the availability of technology alternatives. If alternative technologies are embodied in standardised equipment that is available on an 'off the shelf' basis, it would decrease the commercial value of the corresponding proprietary technology, while for the specially designed product or specially required process, the related proprietary technology would maintain high commercial value. Unfortunately, relatively little pricing information is publicly available to guide the negotiating parties and this causes the complexity of pricing decisions for transferred technology.

Therefore, according to the traditional view, firms may not license their technology unless: (a) the technology relates to products they no longer produce; (b) the technology has potential in a non-strategic geographic area (Hyland, 1993); (c) the full control over the technology is no longer required (Contractor, 1984); and (d) the market where foreign ownership of investment is restricted (Baranson, 1970). As a result, licensing was expected to be employed mostly when extracting the remaining value from a mature technology (Telesio, 1979) from a technologically dominant firm to technologically deficient firms (Contractor, 1981b). Hence, Stobaugh (1984) suggests that licensees should not expect to obtain advanced technologies, because those that are important to the owner's competitive strength may not be licensed (Adams, Ong and Person, 1988), when the firm (the owner of technology) cannot appropriate the full rents from the firm-specific assets (technology) (Buckley and Casson, 1976 and 1988).

Beyond this, Teece (1986a) points out that the pediments to licensing technology assets is, because of the tacit nature of much of the knowledge necessary to exploit the technology, that there is the need to reveal a great deal about a technological advance in order to convince a prospective licensee of the value of the technology. However, Buckley and Carter (1996) argue that the owner of technology has no reason to do so (to license) once it is revealed, and equally important, such tacit knowledge is difficult to understand and that can be appropriated over time (Teece, 1986a).

2.2.3.3 Joint venture

Despite of the preference for FDI in ITT, more investigations of international joint ventures have however shown that a major motivation to form a JV was for technology transfer (Contractor and Lorange, 1988; Kogut, 1988). Compared with internal transfer and contractual technology collaboration, more recently there is growing recognition of the fact that a JV is often a 'first best' strategy (Dunning and Cantwell, 1982; Harrigan, 1985). Referring to the negative advantage of JV, such as limitations of investment requirement and reduction of risks in host countries (Kolde, 1973), Franko (1983) and Herzfeld (1983) argue that the attractions of JVs may be more from the positive advantages.

(i) With regard to transaction cost, Dunning (1991) argues that, on the one hand, the greater the perceived costs of transactional market failure, the more MNEs are likely to exploit their competitive advantages through internalisation rather than externalised activities with foreign firms. On the other hand however, the higher the administrative costs of hierarchies and/or the external diseconomies or disbenefits of operating a wholly-owned foreign venture, the more probable that contractual agreements and/or joint ventures will be preferred. Quelch (1985) also notes that the desire of a firm to spread its costs and risks of in-house activities has been found to be one of the motivations to set up joint ventures.

(ii) With consideration of technology change, Bailetti and Callahan (1993) note that as the pace and breadth of technological progress increase, firms prefer to form international collaborative arrangements, rather than purely in-house R&D/production activities and arms-length market exchange, as the basis for developing competitive advantage from technology.

(iii) In examining exchange of knowledge, Doz, Prahalad, and Hamel (1990) argue that the benefit, which may not be gained by the wholly-owned subsidiaries, is that JVs can provide a fast access to new markets by 'borrowing', or merging, a partner's knowledge: on the one hand, the primary knowledge contribution of foreign partners generally involves technology, management expertise, and global support (Yan and Gray, 1994); on the other hand, to establish an operational presence in a foreign country, a firm must access local knowledge as a means of overcoming market uncertainties (Stopford and Wells, 1972).

Buckley and Carter (1996) subsequently highlight the importance and the increasing needs for a firm to combine diverse kinds of technical and market knowledge from multiple sources. They argue that it is no longer sufficient to have an invention and rely on established routines for manufacturing and marketing new products. New products must be designed in the light of market knowledge about more discerning and diversified customer requirements. Knowledge in one field is of value to firms only in combination with knowledge from other fields. These different kinds of knowledge are *complementary* (Harrigan, 1985), hence their value jointly is significantly greater than the sum of their values when separate.

Pucik (1991) puts the argument forward that the knowledge exchange between the JV partners can be distinguished as those leveraging *resources* and those leveraging *competencies*. Concerning traditional technology transfers, which were often conceived and executed as some form of resource exchange, Itami (1987) argues that the traditional sources of leverage (e.g. economies of scale, low factor costs) are not sustainable in the new global environment, while competencies are fundamentally information-based invisible assets and accumulation of such assets through transfer experience is seen as the foundation for a sustainable competitive advantage. Pucik (1991) further adds that using technology transfer as a point of leverage, competencies in different parts of a value chain can be combined to achieve a distinct competitive edge in the market.

Given the important role of JVs in enhancing firms' competencies, however, as Itami (1987) puts, the market value of such competencies (knowledge and capability), which cannot be readily purchased, is difficult to assertion. Compared with contractual collaboration, on the one hand, Mowery (1992) argues that the problem of determining the value of partners' contributions can be reduced through JV. Partners make financial commitment to a JV that can back their claims for the value of assets they contribute. Because such financial commitment can substitute for the complete revelation of the value and characteristics of the assets (technology) that may be necessary to complete in licensing agreement, and it also allows partners to await an actual market judgement of the value in the future. Chesnais (1988) adds that a firm supplying capital to the JV can closely monitor the use of its contributes assets and thereby reduce its risks of loss. Joint ownership also provides a means of spreading the costs of produce valuable information that could otherwise be protected from appropriation by contractual undertakings.

On the other hand, Doz (1988) argues that even within the jointly financed technology partnership, the value of partners' contributions may not be easily established. This difficulty is compounded by uncertainty about technological and market outcomes in such a venture. The value of contributions is also likely to change over time due to technology and/or market changes, and as such, one partner may shift from a valuation based on contribution to one based on expected results, and show impatience with a divergence from the position of the other partner.

It should be noted however, despite of the difficulty in establishing an agreed value for transferred technology between the collaborative partners, the fast growth of externalised technology transfer (for example see Survey of Current Business, 1994) has in general led to a rising recognition of the importance of collaboration. Ansoff (1987) argues that the increased collaboration reflects a rapidly changing technological environment in terms of the complexity of technology and its subsequent effects on products and markets. Hakansson and Snehota (1989) subsequently raise a question that the strategic considerations for external transfer had been overlooked by the traditional studies. Capon and Glazer (1987) note that, in the fast changing environment, firms appear to be using the full range of options available to them for the proactive use of technology. These more recent strategic considerations of using technology collaboration include: as an access to complementary knowledge (Kotabe, Sahay and Aulakh, 1996); a means to increase market power created by a network dependencies (Hakansson and Snehota, 1989); an effective alternative to in-house R&D through reciprocal licensing arrangements (Telesio, 1984); a tactic to achieve rapid market penetration (Contractor, 1985a; Lei and Slocum, 1991); a method of amortising R&D costs or product development (Ohmae, 1990); a means of establishing standards (Hagedoorn, 1993) and to facilitate organisational learning (Huber, 1991), and an explicit element of a firm's global marketing strategy (Hamel, Doz and Prahalad, 1989; Kotabe, 1992). In response to the emergence of the global market and competition (Dicken, 1992 and 1998; Yip, 1992), technology transfer has been further linked to the context of strategic alliance as an efficient resource for acquiring external knowledge to maximise firms' competitive strength (Grandstrand and Sjolander, 1990; Ohmae, 1989). This more recent theoretical approach which favours externalised transfer implies that the value issue still remains but its impact on transfer strategies has shifted substantially from the firm's *willingness* to transfer technology to other firms to the *effectiveness* of technology collaboration. As Root (1981) comments, "a licensing agreement (author notes: it should also include other forms of collaboration) will remain viable over the longer run only if both parties share in the economic rent created by the technology transfer."

2.2.4 The theoretical development and limitation of the value issue in the context of ITT

As shown from the above review, the discussions of the debate about the value of the transferred technology between suppliers and acquirers were initially focused to the dimension of cost and price. In this dimension, pricing technology was explicitly discussed in the context of licensing agreements. An important feature was identified that there is an element of sharing future benefits between licensors and licensees when a price of transferred technology is determined. This was interpreted as the principle of LSLP (licensor's share of licensee's profit) and a formula was created to calculate LSLP (Arni, 1984; UNIDO, 1983):

$$\text{LSLP}(\%) = \frac{\text{The fee received by the supplier (technology price)}}{\text{The profit of the recipient}} \times 100\%$$

Then, technology price = LSLP (%) x the recipient profit.

However, difficulty has been found in determining the level of estimated profits. Root and Contractor (1981) note that to maximise the share of economic rent, the supplier tends to estimate a higher incremental value when determining the ceiling price. By the same token, as Chen (1996) indicates, acquirers on the other hand tend to estimate a lower incremental value in order to gain more shares from the future profits.

Furthermore, There is a recognition that the complexity of pricing technology is, in many cases, because of its connection with various payment arrangements (Root, 1981). The price of technology comprises a series of payment. It can be reflected in lump sum payment and royalties, and may also be partially compensated by fees for provision of components and technical assistance etc. In addition, Cho (1988) suggests that the "agreement-specific factors", such as market restriction, exclusivity of the license and restriction on the use of technology etc., should also be taken as the determinants influencing the price of technology. Overall, the recognition that pricing technology involves a combination of payments and an element of sharing future profit and may also concerns the agreement-specific factors have shed light on the issue in a broad view and imply the core and context of technology valuation are beyond pricing.

On this basis, the consideration went forward to the measurement of value in a broader perspective. Related to this regard, Steele (1989) suggests that three approaches may be used: (a) focusing on inputs (such as capital and human resources), (b) focusing on process (such as effectiveness and performance) and (c) focusing on outputs (such as market share and complaint expense). However, the difficulty to develop acceptable measure of output was revealed. Concerning the value settlement in ITT, Pucik (1991) argues that the bargaining process and the agreements regarding the transfer primarily address the issue of equitable resource exchange. This was because the resources initially contributed into the operation usually have a specific market value (e.g. patents, equipment, labour) so relatively easy to evaluate. The emphasis here is placed on estimating the value of inputs into the partnership. However, Johnson and Kaplan (1987) argue that the financial measurement which firms often adopt only focus on visible assets, but the measurement cannot provide sufficient information about the value and significant of invisible assets. By this measurement, invisible assets were not viewed as having 'value'.

Further to this argument, Pucik (1991) points out that the difficulties would always come with appraising the value of outputs, because benefits from competencies acquired through the technology transfer process are impossible to assertion a head of time. Technology transfer agreements hence seldom provide for the sharing such benefits. As a result, what could not be measured was consequently left unmanaged. In terms of solution, the emphasis is however on reducing the potential competitive threat by legal restriction aimed at limiting the strategic options available to the acquirers of the technology.

In summary, the related ITT theories recognise that ITT is a well adopted means for the enhancement of the firm's competitive advantages but also reveal the difficulty to establish the value of technology and its impact on the transfer strategies. Difficulties arose from the tacit nature of knowledge, the acquirer's uncertainty of the technology and the owner's unwillingness to 'reveal' the core of knowledge. The early consideration in the value issue was confined to cost and price. However, as value is a broader concept than cost and price, the dynamic nature of value cannot be reflected by means of pricing. More recently, the importance of measuring invisible assets has received attentions which shed light on the concept of value that it may comprise more dimensions in addition to the traditionally focused commercial aspect. The concern of value appreciation to certain extent favours intra-firm transfer, the externalised technology collaboration has nevertheless been recognised as a more preferable form to obtain a greater joint value. This implies that, on the one hand, the value of technology should reflect the enhanced competitiveness that can be obtained by each party, and on the other hand, the value issue and the strategy of technology transfer are closely connected. As the focus of competitive advantage is moving from resources to competencies, the acquisition and accumulation of competencies through technology transfer is increasingly focused (Prahalad and Doz, 1987). This suggests that the issue of technology valuation becomes even more important and critical. However, there have so far been very few explicit studies on this issue under the context of ITT.

2.3 Theoretical Review On Value And Product/Technology Valuation

Porter (1985) argues that value must be established on the basis of mutual acceptance. On the one hand, a firm is profitable if the value it commands exceeds the costs involved in creating the product. On the other hand, value also needs to be accepted by buyers in its realisation. Porter's assessment implies that (a) value comprises an element of utility of product or service to buyers and (b) value must be in competitive terms. Altogether, value is how much buyers are willing to pay for *what* suppliers provide them, which not only includes the price, but also, and more importantly, the benefits/satisfaction that the buyer could acquire. Value of technology is a dynamic variable to be added, but this core nature of technology valuation in an ITT context has not been discovered by the existing literature. Nevertheless, with respect to technology value and valuation, the value engineering approach, customer evaluation method and technology attractiveness evaluation process were found to be noticeably related.

2.3.1 Value analysis approach - the owner's perspective

2.3.1.1 The definition and components of value

Value is defined (in Webster's dictionary) as "a fair return or equivalent in goods, service, or money for something exchanged". From the definition, value should include the following components (Fallon 1971):

- customer needs - market
- function[2] of product - utility to customer (meeting customer needs)
- cost to produce - resources required to create functions
- return through exchange

Given that the major contents of value are (a) functions to satisfy customer needs and (b) cost to create functions, Shillito and De Marle (1992) further point out that the value of a product can be represented by a set of positive and negative features in the product. The positive factors are advantages that reward the owner and the negative factors are disadvantages that

[2] A function is generic statement of what needs to be accomplished without specifying the means. In other words, all the objects can be described by functions (Shillito and De Marle, 1992).

accompany the ownership. The possible advantages for a product, for example, a machine, can derive from its better quality, higher reliability, greater performance, easier maintenance, faster processing speed, shorter production lead time, smaller dimension and lighter weight etc. By contrast, the disadvantages arise from poorer function and/or higher cost. Product value is a function of the ratio between the advantages and disadvantages of similar products.

The value of a product, in the competitive context, increases in proportion to its advantages over competitive products and decreases in proportion to its disadvantages. Items that have high value will displace items of low value in the marketplace. Therefore products and service evolve in a competitive market in which those that best satisfy customers' needs survive. In a competitive market, as Shillito and De Marle (1992) propose, the measure of 'fittest'- *the survival of the fittest* - in the evolution process, is value. Value, in competitive terms, is the directive force underlying an innovation process that continuously creates improved products and services.

2.3.1.2. Value analysis technique

Miles (1961) introduces the technique of *Value Analysis* (VA) by which product value was analysed to provide the necessary function at least cost. Fallon (1971) further argues that today's VA is as much concerned with developing new and better ways or satisfying customers as it is with reducing cost.

From the core value components, it implies that value - the worth of return from exchange - is judged on the basis of the relationship between the functions that satisfy customer needs and the costs to provide such functions, i.e. value can be measured as the ratio of function to cost.

Value = Function/Cost

The maximum value is achieved when the essential function is obtained for minimum cost. Similarly, performance to price ratio is used to describe the value of a product from the customer's view. Good value exists when a product costs little and performs well. Value can be increased by either increasing the performance or decreasing the cost (Miles, 1961). Performance and price are interrelated and depend on the way a product is designed and manufactured.

Customer value = Performance/Price

The equations imply that a good value may also be arrived from the improvement of functions/performance at a greater rate than the rise of corresponding costs. As Fallon (1971) argues, not all the costs are bad and nor is all cost reduction equally good if efficiency can be increased greater than the rise of costs. Miles (1961) also adds that increasing performance can add value "*if the customer needs, wants, and is willing to pay for more performance*". Shillito and De Marle (1992) further propose 'the fittest is the best value.'

The purpose of VA is for enhancing product value by improving the relationship of worth to cost through the study of function. It starts firstly by examining the customer's needs or market demand, then, by defining the function of product, determining the appropriate cost for providing such function, searching for better ways to perform it or better ways to satisfy the needs, and finally by evaluating the options, verifying results, and preparing a plan for implementation (Fallon, 1971).

Therefore, Shillito and De Marle (1992) define the VA as a functionally oriented scientific method for improving product value by relating the elements of product worth to their corresponding elements of product cost in order to accomplish the required function at least cost in resources.

2.3.2 Customer value evaluation - from the acquirer's perspective

Customer value has recently become a topic of keen and growing interest (Parasuraman, 1997). The importance of customer value is highlighted as a source of competitive advantage (Woodruff, 1997). In a hypercompetitive environment, where sources of both product-based and process-based competitive advantage are quickly imitated by competitors (Dickson, 1992; Ghemawat, 1986; Jacobson, 1992), a commitment to customer-value-focused innovation is essential to sustaining competitive advantage. The knowledge of value is considered critical and can be thought of as the cornerstone of marketing strategy (Anderson, Jain and Chintagunta, 1993). It is therefore critical for firms to gain an understanding of their offerings, i.e. the value of their products to their industrial customers, and to learn how they can be enhanced (Wind, 1990).

2.3.2.1 Scope of customer value

Lichtenthal, Wilson and Long (1997) point out that in order to build competitive advantage, firms need firstly to understand what 'drivers' create value for customers. In this regard, one critical aspect of customer value is the *sources* from which customers may derive value (Parasuraman, 1997). Much of the focus has been placed on the attributes related to the product and service of offers, and customer value is inherent in or linked through use of products (Woodruff, 1997). In addition, Ravald and Grönroos (1996) argue that value may also be relationship-related. In brief, measuring the value of the customer relationship and how customers perceive the 'total' value proposition (e.g. product, services, channels, ideas) have been identified as priority topics in recent studies in this area (Lapierre *et al*, 1998).

2.3.2.2 Domain of customer value

Mazumdar (1993) states: "today's value-conscious customers are neither impressed by the best product nor are they persuaded by the lowest price alone. Instead, consumer purchase decisions are often guided by a careful assessment of what benefits they obtain in exchange for the costs they incur to acquire and consume the product." This view has been consistently shared in many studies in this field (Berry and Yadav, 1996; Day, 1990) and on this basis, customer perceived value is defined as the difference between the benefits and the sacrifices perceived by customers in response to their expectations (Haas, 1995; Ravald and Grönroos, 1996; Slater 1996 and 1997). The customers' benefits include the satisfaction of their needs (from product or service) and related relationships (Zeithaml, 1988). The customer sacrifices include the overall monetary and non-monetary costs that a customer invests in order to complete a transaction or to maintain a relationship with a supplier. Non-monetary costs can be defined as the time, energy, effort and conflict involved in dealing with the supplier in order to get the products, services or the relationship discounted (Lapierre *et al*, 1998). The importance of non-monetary costs is particularly emphasised by Carothers and Adams (1991) that "many customers count time rather than dollar cost as their most precious asset."

2.3.2.3 Construct of customer value

A major issue has been identified as the development of customer value measures (Reid and Plank, 1995). In the 'key informant' approach (Huber and Power, 1985; Phillips, 1981), an assumption was made that relatively few key customer value drivers drive customer behaviour. More recently, the use of multiple informants to verify perceptions with regard to the value dimensions and drivers are increasingly adopted.

By multiple approach, Zeithaml (1988) proposes that the drivers of customer value in the benefit dimension may include: (1) alternative solutions, (2) product quality, (3) product customisation, (4) responsiveness, (5) flexibility, (6) reliability, (7) technical competence, (8) image, (9) trust and (10) solidarity in relationship, whereas sacrifice dimension may comprise (11) pricing practices, (12) time/effort/energy and (13) conflict in relationship.

In the study with a focus on industrial IT customers, Lapierre *et al* (1998) further justify the above critical value-based drivers and categorise driver (1) as *product and service related benefit*, (2) and (3) as *product related benefit*, (4) (5) (6) and (7) as *service related benefit*, (8) (9) and (10) as *relationship related benefit*, (11) as *product and service related sacrifice*, (12) and (13) as *relationship related sacrifice*. The results of their statistical test show that the customer value drivers are positively correlated with one another at a significant level. The finding confirms that the value drivers, which are used to justify the customer value, exploit at least three sources: product, service and relationship.

The study confirms that both the benefit and the sacrifice dimensions need to be taken into account to construct customer value. It also indicates that customer value delivery must be based on multiple desired (expected) value drivers rather than focusing on relatively few key value-based drivers. Furthermore, as the customer value is a first attempt at measuring the value perceived by customers, they must therefore be replicated and refined accordingly: if the driver is not creating value for customers, it should be eliminated; if the driver is not a source of competitive advantage for the company, the company should consider outsourcing the activity (Lapierre *et al*, 1998).

2.3.3 Technology attractiveness evaluation - from both supplier's and acquirer's perspectives

Geistauts and Eschenbach (1998) use the term 'attractiveness' to evaluate new technology and argue that "commitment to developing a new technology will only take place if the developing organisation perceives that the candidate technology is highly attractive in terms of probable resulting benefits. This requires sufficiently high probabilities of success for the R&D process and for market acceptance of the resulting technological products, services, or processes. But market acceptance will only occur if potential users in turn perceive the technology as attractive to themselves". Hence the attractiveness of technology for both the developer and buyer is a necessary prerequisite for successful technology introduction.

Geistauts and Eschenbach (1998) develop a general logic of attractiveness evaluation process in which the technology developer's preliminary evaluation of attractiveness focuses on identifiable benefits to itself including the probability of technical success, and its relative competitive strength. As part of the initial evaluation, the developer also needs to estimate the benefits that this technology will provide to users, because the absence of users' benefits will prevent the technology from successful commercialisation, hence the owner's anticipated benefits will not be realised. However, because the goal-set of technology developers and users differ, they can perceive the benefits inherent in a technology quite differently. Nor is their understanding of the technology's nature and performance the same. As a result, the developer's initial estimates of user benefits are likely to differ from those made by potential users. The difficulty of reaching convergent perceptions may arise because the developer fails to fully understand the user needs and/or users are only able to partially appreciate the technology.

To solve the problem, a framework, claimed by Geistauts and Eschenbach (1998), to assess technology benefits was developed. The process includes:

(a) categorising broad benefit groups (such as contribution to technology leadership, manufacturing capability, cost reduction, differentiation potential and market development etc.,

(b) identifying specific benefits or benefit-factors within each group,

(c) estimating the strength of the benefit or benefit-factor,

(d) applying appropriate weights to a group's components, and

(e) evaluating overall results.

The importance of weight assignment is emphasised by arguing that specific component weights cannot be generic. This framework is claimed to facilitate comparative evaluations of technologies, and reduces the possibility that significant benefit components or factors are overlooked.

On the basis of the benefit assessment, a technology commitment evaluation matrix was established (see Figure 2.2). The model takes into account technology attraction to both the owner and users. It provides a guideline to the owner of technology, through positioning in a matrix, for formulating the strategy in terms of level of commitment to a specific technology.

Figure 2.2 Technology commitment evaluation matrix (adapted from Geistauts and Eschenbach, 1998)

Benefits for technology developer	Great	Moderate	Small
Great	• Fully commit to accelerated development	• Continue development • Refine understanding of customer benefits to improve fit	• Increase market research • Modify technology • Segment market into niches • Seek other markets • Educate users
Moderate	• Continue development with periodic re-evaluation	• Continue development with periodic re-evaluation or License technology	• Pursue niche market or • Abandon technology
Small	• License technology • Sell technology to other developers • Limit development	• Sell technology to other developers or • Abandon technology	• Abandon technology

Benefits for technology users

To summarise, the studies on value/valuing assessed the major elements of the value, in which functions and costs from the owner's view, and the benefits dimension and sacrifice dimension from the users' perception, were identified. From these value components the studies revealed that the value is a competitive term which must be acceptable to both sides. Hence, valuing a product/technology requires the assessments of the benefits and costs from both sides. Although these discussions of value/valuing were not linked to technology transfer, the considerations that those studies proposed contribute to the identification of the factors affecting value and to the development of a framework for technology valuation within the context of ITT.

2.4 Theoretical Review on The Issues Related to Technology Valuation Within The Context of Transferring Technology Into China

2.4.1 Overview

The number of studies related to the transfer of technology into China have been enormous. There have been more than 200 journal articles (from several global sources including ABI data base) with a specific focus on discussion of this issue since the early 1980s to date. The early studies related to the issue were however largely characterised as environmental studies.

By the end of June 1999 there has been over 332700 foreign investment enterprises with a total investment value of nearly US$600 bn in China (People's Daily, 1999). The recognition of FDI's important role in improving the local productivity and resource allocation efficiency through technology transfer (Bassolino and Tse, 1999; Sun, 1998) was however coupled with the increased awareness of internal inadequacies which affected the transfer effectiveness (Hanes, 1998). Increasingly and more recently, studies have given more attentions to the internal issues such as, organisational hierarchy (Simon, 1989), objective and strategy (Vyas and Shah, 1990), management deficiency (Ball *et al*, 1993; Liff *et al*, 1993; Martinsons and Tseng, 1995; Steward, 1991), technical (Simon, 1992) and marketing (Chan *et al*, 1993) capability inadequacy and the process of implementation (Miller and Rushing, 1990), which have been recognised as critical factors in the process of technology transfer into China. Researchers also became involved in more detailed specific enterprise case studies where technology transfer agreements are being and/or have been implemented. The relationships and friction between foreign and Chinese partners were exposed, the actual differences and difficulties were more understood and recognised (Von Glinow, Schnepp and Bhambri, 1991), and the success and/or failure factors were accounted for (Campbell *et al*, 1988; de Bruijn and Jia, 1993). Coupled with in-depth case studies, forms of transferring technology were explored and compared (Teagarden, 1990; Yan and Gray, 1994). The transfer benefits and 'disbenefits' have also been assessed from the point of view of macro-economic development

(Lin, 1990; Tidrick, 1986) to more firm-based strategic collaboration and management (Goldenberg, 1988; Lin and Germain, 1998).

Until the author's current research, there was however no study with a specific focus on technology valuation within the context of transferring technology to China being carried out. Some regulations are however related to technology valuation which are presented below. Apart from them, only few studies indicated the value issue. de Bruijn and Jia (1993a) notice that there is a debate on the value of technology between foreign suppliers and Chinese acquirers. Zhao (1997) also identified that value of resource is one of the key elements in ITT negotiation and submitted that psychological factors in conjunction with economic factors exert influence on the process and eventual outcome of an ITT negotiation. Martin (1995) notes that, in some cases, Chinese firms tended to demand a high value of their resource input (e.g. land) in order to offset the high value of imported technology. Those studies demonstrate an awareness of the value issue but no investigation has been made for solutions. Nevertheless, discussions on the effects of related regulations, transfer objectives, forms of collaborations, factors affecting transfer efficiency and problems encountered in the process of technology transfer, provide a background in China to the research question. Some issues being raised in these studies are closely related, hence their implications for technology valuation need to be taken into account in this research. The following are the related discussions being selected from the existing literature.

2.4.2 Related regulations: pros and cons

The technology imports in China can include the following components: patents, proprietary know-how, computer software, technical data, specifications, trademarks, technical consultancy, design, research and development, and equipment or production lines (Sun, 1998).

Further to the definition of technology components, China formulated technology import regulations as a guideline for local authorities to evaluate potential transfers. They provide criteria for technology suppliers to select technology and judge the appropriateness of transfer to the Chinese market. The regulations state that:

> Imported technology should accomplish one of the following attributes: improve production safety; improve resource utilisation or enhance environmental protection; develop and produce new products; improve the quality and performance of products; reduce production costs; improve market and price competition; reduce energy or raw materials consumption; increase product exports and earn foreign exchange; advance science and technology or improve management skills (MOFTEC, 1985).

Moreover, there are also some regulations on the FDI objectives in varying channels whereby the transfer of technology is undertaken. The regulation for establishing an equity partnership, for example, states the following expectations: (a) encourage exports, (b) bring advanced managerial techniques to China, (c) bring technological expertise to China, and (d) deliver managerial and technological training to Chinese nationals. Meeting with these requirements a JV can receive an approval from the government (Glasser and Pastore, 1998).

Coupled with the expectation for technology, some favourable terms are specifically offered to the foreign investment with a commitment to improving China's technological capabilities through technology imports, such as allowing a longer period for technology transfer contracts and preferential tax treatment for the payment of the transfer (Bassolino and Tse, 1999). Technology as part of investments in foreign investment enterprises (FIE) was also allowed to encourage transfer (Kuzmik and Burke, 1993). It indicates that technology can be treated as a part of the capital contribution, hence technology transfers can lower the required monetary portion of a foreign firm's contribution to a JV. Under the rules, the value of the technology transferred cannot exceed 20 percent of the one party's capital contribution to the venture (MOFTEC, 1990). It has been seen that many foreign companies reduced start-up and expansion costs by incorporating equipment, know-how, drawings, processes, or other intangible technology-related assets as part of the registered capital in an FIE (Bassolino and Tse, 1999).

The regulations that govern the technology transfer regime in China, on the other hand, may imply, to a certain extent, some side effects for potential technology suppliers (Bassolino and Tse, 1999). An immediate example can be drawn from the above regulation that the technology contribution is limited to 20% of total investment, as Young and Lan (1997) argues, this may cause reduction of willingness for the foreign investment with the feature of high-tech element as they may expect a higher technology share in their investment. Another argument is in connection with the regulation on the licensing agreement. The provisions of technology transfer state that the term of a transfer contract in China should correlate with the length of time for a transferee to master the technology. After the termination of the contract, further restrictions on the transferee's continuous use of the imported technology require special approval (MOFTEC, 1985). Concerning this regulation, Bassolino and Tse (1999). argue that it implies that the technology, with an approval, can be the property of the licensee or recipient at the end of the transfer contract, which means that use of the technology is no longer restricted by the provisions of the contract. For technology suppliers, the real question is then whether they can recover the technical documentation and materials relating to the technology at the end of the contract (Tao, 1998). It raises a requirement for technology suppliers to ensure the value of its transferred technology can be fully achieved within the period.

2.4.3 The Chinese Government's technology valuation methods

Methods for technology valuation are required in order to carry out the regulation of the technology contribution to the capital investment. The valuation process is governed by several Chinese authorities including the State Intellectual Property Office. Under the authorities' permission, a foreign investor can appoint a Chinese licensed valuation firm to perform the assessment. However, disputes often arise from the valuation methods currently used in China. Sun (1998) reveals that the most common method used in connection with valuation in China is *discounted cash-flow*. Under this method, the project earnings derived from the technology over the contract period, plus the residual value of the technology or intellectual property, are capitalised at a discount rate to determine the present value. Two other methods, the *comparable price* method and the *replacement cost* method, are used to predict the value of intellectual property. In the comparable price method, the value of a piece of intellectual property is determined by comparing with the price of a similar piece of intellectual property in China. However, it is often difficult to find comparable items on the market, and this issue often complicates the negotiations between the suppliers and acquirers. The replacement cost method uses the value of reproducing the technology as the basis of valuation. The difficulty of valuing intangible know-how is recognised but there is little guidance for judging intangible property from these methods. The only judgement is its technical applications (Bassolino and Tse, 1999) and the reference to the price of products transferred that would normally be agreeable to an unrelated party (Huang and Tsoi, 1998).

The authorities will not approve a contract if they consider the price of the technology unreasonable (Bassolino and Tse, 1999; Martin, 1995). However, the judgement is only made within the cost/price dimension. In comparison with an arm's length based reference price, the comparability remains in the scope of static technical data such as: product name, specification, model, function, structure, appearance, package, etc. (Huang and Tsoi, 1998) and no measures for evaluating dynamic value generation, technological capability enhancement and strategic development are considered.

2.4.4 Motivations of foreign companies for technology transfer

The reasons for transferring technology into China fall into proactive and reactive aspects. By proactive reasons foreign companies are motivated to seek perceived benefits derived from technology transfer as well as strategic considerations, such as (Young and Lan, 1997; Zhao *et al*, 1997):

- access to a growing market because existing markets were saturated
- lower operating costs
- opportunity to design and build a new facility to make the best use of technology
- access to the future needs of customers
- cost-effective manufacturing facility using low cost labour and materials
- further exploit knowledge and skills
- as a part of global strategy.

By reactive reasons foreign companies are under pressure by Chinese policy to enter into technology transfer arrangements as a condition of entering the market (East Asian Executive Reports, 1994). The underlying Chinese industrial policy is to use its vast market potential as leverage to get foreign firms to invest in China's industrial development. The policy is coupled with some restrictions or high import tariffs on the activities of direct imports, pure sales and service operations or the use of sales agents without a manufacturing element. As a result, such operations would either be placed at a price competitive disadvantage or have shortcomings in that only limited scope of business activities are allowed. To be competitive in the local market foreign companies must establish a manufacturing operation as the vehicle for direct participation in local sales and service (East Asian Executive Reports, 1994). When this reactive reason applies to foreign companies' motives, a short-term benefits-driven strategy is often adopted.

2.4.5 Understanding divergence between partners

Areas of divergence between partners have been found to be a critical problem in many collaborative ventures in China. "*Sharing the same bed but having different dreams*"- this Chinese proverb came true in many collaborative ventures (Tao, 1998). The divergence between partners are mainly as following:

2.4.5.1 Divergence in knowledge acquisition goal

The problem is more often encountered in a solid form of collaboration such as a JV. Webster (1989), and Prahalad and Hamel (1994) highlight that the goals of JVs go beyond mere economic benefits and knowledge acquisition should be included. Davidson (1987) and Von Glinow and Teagarden (1988) further add that knowledge and its acquisition and learning are critical to international joint ventures in China. For example, when a JV is formed, the contribution of local knowledge by the local partner has strategic value to the foreign partner. This is because until the foreign investor acquires sufficient local knowledge to operate autonomously, the foreign partner will continue to depend on its local partner (Inkpen and Beamish, 1997).

However, Si and Bruton's study (1999) revealed that the Chinese and Western partners placed significantly different priorities on knowledge goals. Chinese companies place emphasis on those features which they have not currently mastered, such as technology, management and operation skills and capital understanding. On the other hand, foreign companies focus on their own radically different gaps such as understanding the local market, government policy, and the political and economic system. Yan and Gray (1994) found that misunderstandings arose from the Chinese and foreign partners not often specifically addressing their knowledge acquisition goals so they may not be fully aware of the divergence.

A measurement criteria to judge the success of a joint venture is the knowledge transfer and the synergy that brings to the JV (Harrigan, 1985 and 1988; Kogut, 1988). Given this recognition, Si and Bruton (1999) further argue that dissatisfaction with the performance of many joint ventures in China can be a partial result of their inability to properly assess their knowledge acquisition goals. The lack of understanding of each partner's knowledge needs may be the root cause of the poor performance in many international joint ventures. From Si and Bruton's (1999) findings it showed that, in 50% of their sample (JVs), neither party expended adequate time and resources to consider their knowledge acquisition goals. The ignorance of such needs has led to a substandard performance which virtually became a critical issue to a joint or collaborative venture.

2.4.5.2 Divergence in strategies

Divergence in strategies is equally important in affecting synergy in collaborative ventures. Peng (1997) points out that many foreign companies enter the Chinese market with a long-term strategy and may be willing to absorb initial periods of slow growth for the sake of greater long-term returns. They may wish to initially enter the Chinese market with certain product lines as part of an overall strategy of future expansion into additional product lines. Thus, as Chow (1998) found, the initial start-up period and costs associated with the joint venture may be disproportionately burdensome in order to prepare the local market for the introduction of other businesses at a later time. In the case of some foreign companies who have already had a substantial presence with a network of operations in China, they may have a long-range strategic plan for the entire Chinese market with specific roles for each JV. As a result, they may decide to balance and regulate the growth and production of each venture within an overall plan. This may involve shifting production from one operation to another to pursue logistical efficiency. Their long-range plan may involve slower rates of profitability in the short-term in exchange for greater market penetration and higher profitability in the future (Chow, 1998).

On the other hand, Osland and Cavusgil (1988) found that the Chinese partner tends to view the joint venture in isolation and be more concerned with short-term profits. This may be because of the external pressure from the authority of the industry which often puts a request on the Chinese state-owned firm to reach certain production and revenue targets within a period of time (State Council, 1997). Hence Chinese partners may appear to gain the immediate profits but be reluctant to reinvest profits to seek long term market share as foreign partners would wish (Hanes, 1998). Chow (1998) further argues that even without external pressure, the Chinese partner may not appreciate the foreign partner's long-range perspective and have little sympathy when the foreign firm seeks to shift production from one operation in question to another in pursuit of overall market goals.

2.4.5.3 Divergence in technology/product selection

Although both technology suppliers and acquirers shared a common view to use technology as a competitive tool, de Bruijn and Jia (1993b) found that there was a divergence in technology/product selection. In general, Chinese partners showed a preference for the selection of a latest technology/product so as to develop a technology leadership in the local market. The objective of collaboration, which is always emphasised by the Chinese partner, is that imported technology/product should contribute to improving the local partner's technological capability. Foreign partners, on the other hand, preferred to select a product based on their product range and/or global competition strategy and the compatibility of technology/product with the existing level of production capability in China. Moreover, Chinese companies also placed emphasis on localisation since the localisation process allows them to assimilate foreign technologies and reduce foreign currency demand (Jia and Bilderbeek, 1992). From the foreign investor's view the process of localisation needs to be made in accordance with the capability improvement as well as qualified local suppliers. In the view of local technological capability, Chinese partners often showed confidence in their ability to assimilate technology while in many cases foreign counterparts assessed that this was overestimated (de Bruijn and Jia, 1993b).

Further to the divergence in selection of technology, Ostroff (1995) suggests some useful precautions in order to avoid being misunderstood and confronted with unexpected demands:

- confirm partner's input resources,
- spell out all details of technology/equipment to be provided,
- ensure input quality by verifying the quality of locally made substitute components,
- ensure the raw materials used in the buyer's industrial process are suitable for the imported technology and available when needed, and
- specify operating conditions to match technology/equipment requirements.

2.4.5.4 Divergence in performance evaluation criteria

Satisfaction is normally used as a global measure of performance (Beamish, 1993). The degree of satisfaction has been found to be positively correlated with the profitability of collaborative ventures (Geringer and Hebert, 1991). However, some studies on the performance of Sino-foreign joint ventures showed mixed results. In Davidson (1987) and Stelzer's (1992) studies, satisfaction with JVs' performance were reported while during the same time, dissatisfaction results were also shown by Campbell (1987a and 1987b) and Beamish (1993). Osland and Cavusgil (1998) further argue that these inconclusive results were due to the ignorance of the divergence in performance evaluation criteria between parties. Their findings show that in the evaluation of performance, technology transfer (including technical and managerial know-how and skills) and foreign exchange earnings, remain as important criteria on the Chinese side, while foreign partners seem to derive satisfaction from a greater extent to which they are in the control of the JV. The JVs' strategies for the next stages were seen to be affected as a consequence of the different view on the performance between parties.

2.4.6 Critical factors for an effective technology collaboration in China

There have been many discussions on the problems in varying aspects encountered in technology collaboration in China (e.g. Andersen Consulting, 1995; Allen *et al*, 1995; Beamish and Wang, 1993; Child, 1994; Child and Markoczy, 1993; de Bruijin and Jia, 1993a; Eiteman, 1990; Shan, 1991). From those studies, the predominant problems which related to the research issue can be summarised as: (1) divergent business vision and strategy; (2) inappropriate assessment of the value of technology; (3) unsuitable selection of technology; (4) inappropriate commitment or poor working relationship between partner; (5) inadequate knowledge to choose the right partner; (6) lack of cost control; (7) unsatisfactory product quality and (8) incompetitive product pricing.

Given such problems in collaborative operations in China, the question arises as to what challenges foreign companies are facing and what solutions are available. Page (1998) and Yang (1998), from their recent studies, identified the factors critical to the success of technology transfer in China. These factors include: (1) in-depth research combined with local market sensitivity; (2) long-term commitment to the Chinese market and a well-defined strategy; (3) predeparture training and feasibility studies; (4) first-class products that have been adapted to local market needs; (5) effective use of local resources; (6) a good brand name image; (7) finding qualified local partners; (8) winning trust from partners and (9) developing good human resource management. In addition, O'Connor and Chalos (1999), from their latest empirical findings, posit that foreign investors need critically to give attention to: (a) the proportion of each party's contributions to risk exposure; (b) the competitive cost structure of products in designate markets; and (c) management control over the internal operations. In their case studies, foreign partners were exposed to a greater amount of risk relative to their respective contributions which often led to a drawback decision when difficulties arose. The quality to price ratio of the jointly made products was incompetitive in the local market. The costing system did not integrate financial accounting and production figures which often led to a cost-ineffective internal operation.

Factors specifically related to the solid and long-term collaboration arrangement, such as a joint venture, have also been highlighted. On the one hand, Bailetti and Callahan (1993) argue that transfer of technology from one organisation to another is often a complex and subtle process. As a solid and long term arrangement, a JV is by nature an effective means to facilitate such a process in by both partners closely working together to deliver and gain the full complementary assets from each other. Many studies also conclude that Chinese companies have a stronger preference for JVs compared with other low-commitment arrangements (Tsang, 1995), for they provide better opportunities to access a complete package of know-how (Dutta and Merva, 1990), facilitate organisational learning (Huter, 1991) and improve absorptive capability as they could receive more technical support (Cohen and Levinthal, 1990). From the foreign company's perspective, McElligott (1995) adds that a JV is in addition less risky than looser arrangements in terms of control of technology.

On the other hand, O'Connor and Chalos (1999) point out that specific attention should be given to a solid collaboration. They argue that to ensure long term commitment to the development in the Chinese market, the foreign party must initially undertake a careful study of local market potential for a targeted output before committing to such long-term projects. A recent report (World Trade, 1997) highlights the vital importance to update the technology in the whole duration of collaboration and to provide continuing training schemes. It reveals that most long-term collaborations fail because, after a couple of years, the technology that was initially transferred would lose its competitive advantage. Ostroff (1995) also suggests that foreign partners need to make greater efforts including provision of sufficient technical, management and marketing support because it will take considerably longer to recoup their technology investment in long-term collaboration arrangement.

2.5 Issues For Research

This chapter has so far outlined the theoretical grounding of ITT linked to the issue of technology valuation. The scope of the aspects presented is wide and theoretical approaches are diverse. This is because of the complicated nature of ITT and within this the complexity of the technology valuation process. Under the context of ITT, technology is valued when being transferred which implies how it will be used in the ITT process. As such, the feature of dynamically generating and sharing value in the valuation process naturally links to various dimensions in a broad context, where there would be interrelations and interactions among the factors affecting value. On the other hand, the review also suffers from theoretical limitations. The existing literature does not provide a focused and streamlined package of knowledge on the research issue. The overall guidance from current theories to the research investigation has not been structured. The limitations arise because the awareness of the value issue in ITT has not led to a breakage of pricing for solution, while studies on valuing are not in the context of ITT. Although the importance of invisible assets measurement was raised, the attention still confines to financial results (market sales) while the valuation should aim at the best use of technology which embraces much more complexity and dynamic implications. Nevertheless, some significant implications can be drawn from the current knowledge to help set the research hypotheses, inform the research investigation and ground the findings.

2.5.1 Implications from related theory of ITT: the best use of technology and achievement of the greater added value

Technology changes challenge firms' competitive advantages and innately call for firms to effectively use various resources. ITT is seen to be commonly adopted to acquire complementary assets so that competitive advantage can be enhanced. Strategies in terms of forms of transfer are a key to affect the effectiveness of use of technology, hence have an impact on how the value is added in the value chain. Each partner's contribution to the generation of a joint value needs to be fully recognised. Transfer benefits, costs and risks are differ among alternative arrangements hence should be specified and compared. The achievement of a greater value only arrives at best use of technology in an efficient technology collaboration. It therefore implies that the value of technology is not only concerning its existing worth, but the future added value also needs to be taken into account.

2.5.2 Implications from valuation approach: value component and assessment

To the owner, the components of value include the function that product/technology can provide to users and the cost to produce the function. To the acquirer (buyer), in addition to the judgement of the extent to which its needs can be satisfied by the provided function from the product/technology, the acquirer also requires relevant supporting services from the owner to ensure that the full utility of the product/technology can be achieved. The relationship between the owner and acquirer may also be considered as a beneficial part to add the value, because it helps the owner to develop a customised product, and, on the other hand, it also reduces buyer's risk and resource (time/effort) spent in sourcing the supplies. More importantly, value must be acceptable to both sides. Value is competitive and attractive only when it can provide a greater return to both sides. In order to achieve the best value, the user's requirements need to be specified; the improvement of functions needs to be compared with the corresponding costs; benefits derived from the use of product/technology need to be identified; benefit factors (i.e. the factors that contribute to the benefit generation), as well as their strength (weight of contribution to generating benefits) need to be assessed in order to maximise the value cost-effectively. These methods and techniques provide a significant guidance to value assessment in the technology valuation framework.

2.5.3 Implications from ITT issues in China: factors affecting the value of technology

The discussions on ITT in China provide a more detailed context where the research investigation is carried out. The current government regulations imply an intellectual property issue from which it raises the importance of technology valuation. The inadequate methods currently being used by the government for valuing technology indicate that the problems in technology valuation remain unsolved. The dual dimensions of motivation for transferring technology between partners imply different transfer strategies which subsequently affect the technology valuation. Problems revealed from these studies highlight some aspects which need to be taken into account in field studies such as: divergence in transfer objectives, expectation of knowledge, selection of technology, perceptions of transfer strategies and arrangements, assessment of local capability and management issues etc.

In a brief summary, the existing literature regarding ITT and valuing technology recognised the importance of technology valuation in the context of ITT but has not carried out further focused exploration. The implications from the literature are however employed to design the research with detailed issues to be carried forward for investigation. The next chapter introduces the research design and methodology.

CHAPTER THREE
RESEARCH DESIGN AND METHODOLOGY

> "Facts do not simply lie around waiting to be picked up. Facts must be carved out of the continuous web of on-going reality, must be observed within a specified frame of reference, must be measured with precision, must be observed where they can be related to other relevant facts. All of this involves methods."
>
> (Rose 1965, quoted by Ghauri, Gronhaug and Kristianslund, 1995)

3.1 Introduction

Theory is "a set of interrelated concepts, definitions and propositions that presents a systematic view of specifying relations among the variables with the purpose of explaining and predicting phenomena" (Zaltman *et al.*, 1982). Through the literature review, the lack of studies with a specific focus on the issue of technology valuation within the context of ITT, and hence the limitation to explain it, have been recognised. Nevertheless, the existing literature provides a guide to position the research and identify relevant concepts and to adjust them to the problem under scrutiny. The implications drawn from the current knowledge would assist the research investigation in identifying key factors, specifying relations and constructing theoretical explanations.

This chapter has a dual role: research design and methodology. In the design part, it defines the research domain in which the research focus is distinguished from the past studies; introduces basic concepts of the research question; establishes research hypotheses and presents the focused dimensions for field study. In the methodology part, it describes the research investigation framework; introduces questionnaire surveys and case studies and specifies research methods and techniques for data analysis.

3.2 Defining A New Research Domain: The Distinction From The Past Studies

3.2.1 A dynamic approach to technology valuation

The theoretical review in Chapter 2 demonstrated the awareness of the research issue associated with ITT. More importantly, it allowed the identification of areas where a contribution can be made through further studies. While there is a recognition of technology valuation as being a critical question in technology transfer practice, it has been seen that this issue is still a relatively 'uncultivated' area in related academic studies. Previous research in the related areas were found to be either too general, such as studies on technology transfer strategies, to establish an *explicitly focused* research domain for the further assessment of this issue, or too 'tailor-made', such as studies of pricing technology, to reflect the *specific nature* of technology and its *broader* impacts on technology valuation.

Technology by its nature can be regarded as a primary force to create returns (Porter, 1980 and 1985). Hence unlike other products, the value of technology not only includes its existing value (i.e. development, production and transfer costs etc.) but should also reflect its future value to be generated by using the technology downstream. The consideration of future value when valuing technology is even more significant because the majority of the objectives for technology transfer seek continuous benefits through on-going collaboration. Future value is not only the source of the technology acquirers' benefits but is also an important part of the owners' return (Bennett *et al*, 1997b, 1997c and 1997d). It would be inadequate to confine valuing technology only to the measure of its existing worth. Instead, it would be more important to explore the future value that can be gained to both parties. Technology valuation therefore requires a consideration of how to achieve and share greater added value.

However, studies on the cost-based pricing do not cover, or mainly investigate, the valuation for future value, nor consider cost sharing through the process of future value generation and the implications for the value. Instead of cost calculation and price determination, the capability embodied in technology to yield future returns is essential for value establishment. The core of technology valuation would be the '*quality*' of the capability (technology) in generating future value and the *effectiveness* of the transfer arrangement for best use of such a capability. Thus, a dynamic approach comprising future value generation and realisation is adopted in this study.

3.2.2 A broad view of the value of technology

As technology is by nature a capability which provides a value creation function, and because of its dominant role in the value generation process, its value may not only reflect financial and technological benefits, but also include strategic implications to both suppliers and acquirers (Bennett *et al*, 1997c). The total amount of future gains to be generated through technology collaboration is dependent on the level of, and degree of effective utilisation of the technology capability (Cantwell, 1991).

On the other hand, when transferring technology each party also incurs costs and bears risks. The arrangements of sharing benefits, costs and risks between partners imply their efforts made to the collaboration hence may affect substantially the effectiveness of use of technology. Owing to each side being insufficiently aware of the other side's objectives and expectations (Si and Bruton, 1999), the actual arrangement of sharing benefits, costs and risks has often been found without incorporation of financial, technical and strategic interrelations. This may lead to a divergent view in performance evaluation between partners (Osland and Cavusgil, 1998) in some cases, or the judgement was only based on the financial profitability as it is positively correlated with the degree of satisfaction (Geringer and Hebert, 1991) in some others. It has led to a principal cause of failure: the 'value' of the technology not having been adequately determined. The recognition that valuing technology cannot be isolated from the context of specific technology transfer arrangements, where requirements in these three aspects are specified and linked (Bennett *et al*, 1999b), has not been theoretically addressed. Nor has an integrated consideration of all financial, technical and strategic dimensions been found in the previous studies linked to product/technology valuation. This study takes a broad view of the value, comprising all financial, technical and strategic dimensions and their interrelations in the process of technology valuation.

3.2.3 Research contribution

The intended contribution of this research is to create a new dimension to existing knowledge regarding the issue of technology valuation within the context of ITT. The development of a grounded theory requires the conditions to be specified that give rise to particular sets of action/interaction pertaining to a phenomenon (Strauss and Corbin, 1990). It implies that a fresh perspective is needed. The study hence attempted to consider all the factors to be potential relevant to the research issue being studied and to explore the resulting consequences based on the empirical evidence. The research investigation, with a focus on a particular industry specifics, allows the study to improve the understanding of the phenomenon in the

ITT context, where there is a limited theoretical recognition. The research analysis was carried out with an adoption of a dynamic approach, and a specific consideration of the interrelations between financial, technical and strategic issues. A broad concept of the value of technology and the dynamic nature of technology valuation process are to be established. By testing research hypotheses the study seeks to establish a relationship between the critical factors affecting technology valuation. A distinctive conceptual framework which reflects attributes of these factors in their contribution to value generation and realisation is developed. The framework for technology valuation is to create new insights and add to present knowledge on this specific issue.

3.3 Technology Value Concept And Major Components

The value of an industrial product is determined by the relationship of worth and cost conformed to the customer's needs in a given situation (Fallon, 1971). The value of technology can be, theoretically, defined as its 'worth of utility' including cost effectiveness and performance efficiency, or in the business terms, as the gain that can be made by ensuring its best possible use.

The effectiveness of technology is dependent on upstream activities where the technology is developed and manufactured, while the effective use of technology substantially subject to downstream activities in the context of technology transfer. The value of technology hence will vary at particular points along the technology "value chain" depending on the balance between a number of value components that reflect the performance of these activities. In this study, technology valuation is within the context of technology transfer in which the value of technology comprise two major components: the *"owner's value"* and *"transfer value"* which reflect the supplier's and acquirer's activities respectively. The concepts of owner's value and transfer value were initiated previous to this study but further developed along with the in-depth research investigation.

(i) The owner's value

The 'Owner's value' is the current worth of the technology to the owner. This is based on the cost of its development, production and distribution together with the cumulative costs of any other upstream activities (for example, those incorporated in the cost of components and other inputs) and opportunity cost considerations (for example, where the market value of the technology is lower than the cost of its development because of obsolescence) (Bennett *et al*, 1997b).

(ii) Transfer value

'Transfer value' is the potential worth of the technology to the acquirer, taking into account the proportion of added value generated further downstream in the value chain which could be captured by the acquirer. Transfer value would also be of relevance to the supplier where a royalty is to be paid or a share of benefits can be gained in return for the use of the technology by the acquirer (Bennett *et al*, 1997b).

The owner's value and transfer value are regarded as basic value components. Factors affecting these components will be further assessed to serve the analytical requirements for the development of a technology valuation framework.

3.4 Research Hypotheses

The purpose of technology valuation is to achieve the best use of technology and efficient collaboration. In doing so the fundamental questions regarding technology valuation and collaboration are how to generate a greater joint benefit through a collaborative venture and how to share these collective gains between the two parties, taking into account the owner's and acquirer's different perspectives. The research hypotheses are based on the fundamental questions:

Hypothesis 1: there is a close relationship between the value of technology and returns of using the capability that the technology can offer to both suppliers and acquirers through technology transfer.

Hypothesis 2: the returns which can be captured from technology transfer are substantially influenced by the transfer features and arrangements for sharing benefits, costs and risks between suppliers and acquirers under specific forms of collaboration.

As mentioned above, technology can generate added value in the process of its use. The assessment of the value of technology therefore is made with regard to both total value and to the breakdown of initial value and future value. Hypothesis one primarily focuses on the total value of technology regarding the *'quality'* of its capability, while hypothesis two further comprises total value generation as well as value realisation in connection with initial and future value.

Following the hypotheses there are two breakthrough points that the study takes:

i) From hypothesis one: valuing technology is to evaluate its capability on how much total returns can be generated. It judges the value of technology by examining the total returns derived from transferring/acquiring the capability.

ii) From hypothesis two: valuing technology cannot be isolated from the context of collaboration arrangements. There are two impacts on the value of technology which will be examined: (a) how does the specific form of collaboration influence the generation of the total value? (b) how does the specific form of collaboration influence the realisation of the total value in the forms of initial value and future value?

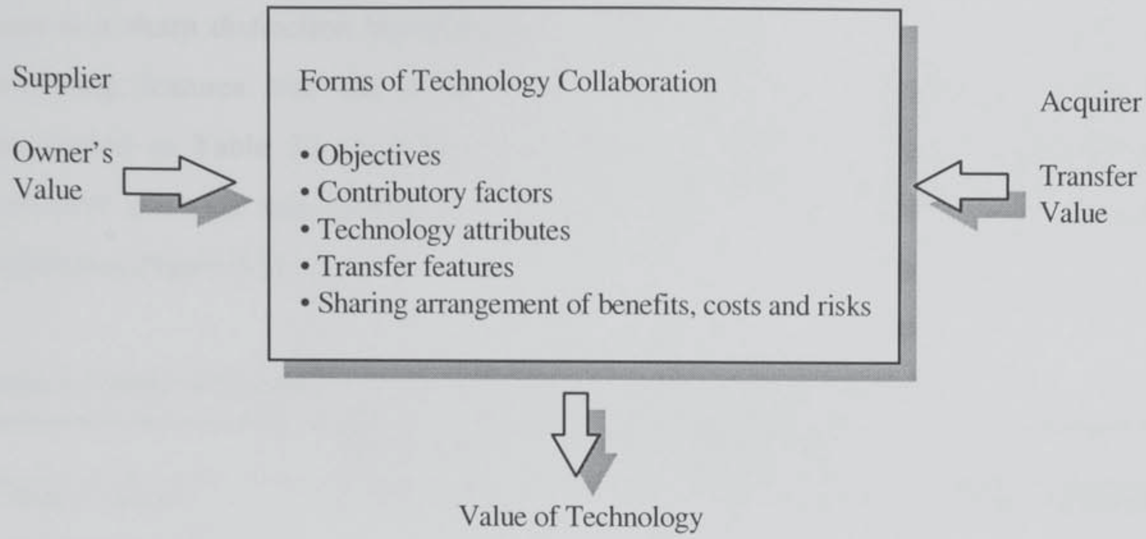
3.5 Research Framework

> A distinction in research is between that which is concerned with *verification* and that which is concerned with *discovery*. In the former type, theory serves as a framework to guide verification. In the latter, theory is the 'jottings in the margins of on-going research', a kind of research in which ... the conclusions are not known before the investigations are carried out (Gherardi and Turner, 1987; p.12).

3.5.1 Research design

The research focuses on identifying and examining the major factors affecting value as well as their interactive effects on technology valuation from both the supplier's and acquirer's perspectives. The value generating, capturing and sharing are considered within the context of specific forms of collaboration. Key dimensions include suppliers' and acquirers' objectives for technology transfer, transfer benefits, costs and risks, transfer arrangements and features, contributory factors, technology attributes, and the impacts and implications from all the above dimensions on the value of technology (see Figure 3.1).

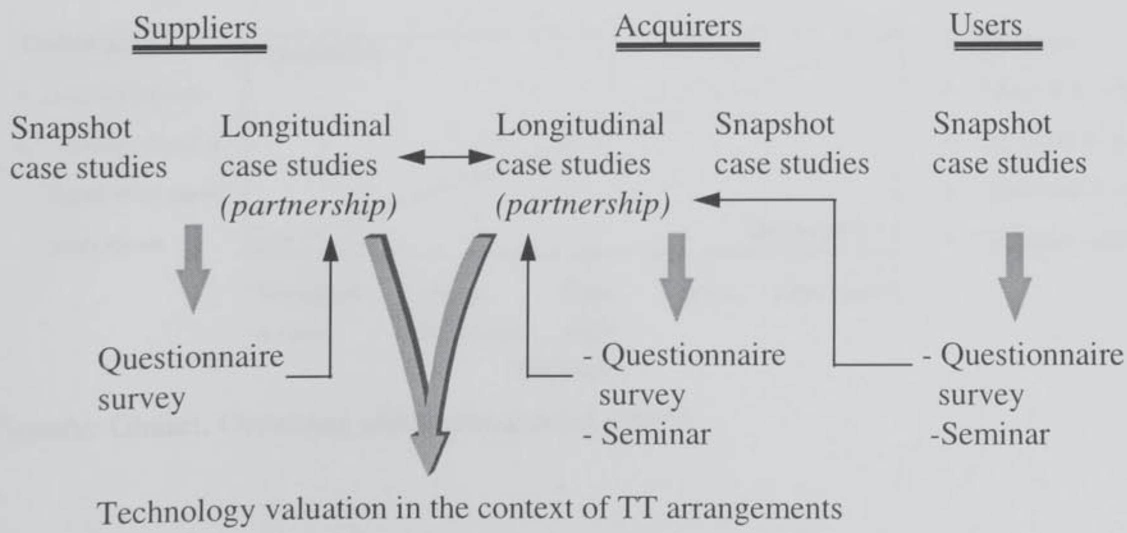
Figure 3.1 Research Design



3.5.2 Investigation framework

The general investigation framework is shown in Figure 3.2. Data were gathered in three groups: machine tool manufacturing technology suppliers in the UK and acquirers in China, and machine tool users in China. Questionnaire surveys and snapshot case studies (unit of observation and analysis) were included within the three groups. A seminar was also held among acquirers and users with participants from over 30 companies. Five 'pairs' of companies, comprising five UK companies involved in transfer agreements with five of the Chinese companies, were taken as the longitudinal cases.

Figure 3.2 Investigation Framework



3.5.3 Research methods: qualitative and quantitative approaches

There is a sharp distinction between quantitative and qualitative approaches and the major contrasting features that are often ascribed to these two methodology paradigms are summarised in Table 3.1. It follows that there are differences between quantitative and qualitative methods and techniques (Jankowicz, 1991) which determine how a subject is studied (see Figure 3.3).

Table 3.1 Some differences between quantitative and qualitative research

	Quantitative	*Qualitative*
• Role of research	• Preparatory	• Means to exploration of factor's interpretation
• Relationship between research and subject	• Distant	• Close
• Researcher's stance in relation to subject	• Outsider	• Insider
• Relationship between theories/concepts and research	• Confirmation	• Emergent
• Research strategy	• Structured	• Unstructured
• Scope of findings	• Nomothetic	• Ideographic
• Image of social reality	• Static and external to actor	• Processual & socially constructed by actor
• Nature of data	• Hard, reliable	• Rich and deep

Source: Bryman (1988)

Figure 3.3 Qualitative and quantitative methods and techniques

Aston University

Illustration removed for copyright restrictions

Source: Ghauri, Gronhaug and Kristianslund (1995)

With the identification of the differences between the two research methods there is a belief that quantitative and qualitative methods are complementary and should be used as, and when, appropriate depending on the focus, purpose and circumstances of research (Ghauri, Gronhaug and Kristianslund, 1995). In other words, research methods and techniques should be chosen according to their suitability for the research questions and objectives. A qualitative method is most useful for identification of factors (e.g. objectives and perceptions etc.), hypothesis building and explanations, particularly for research of an inductive nature (Miles and Huberman, 1984; Strauss and Corbin, 1990). As this research was based on empirical evidence, with a focus on understanding and assessing a phenomenon, the induction method was basically employed. For the data which were collected through interviews and case studies, where findings cannot be arrived at by statistical methods or other procedure of quantification, the qualitative method was used as an essential tool. However, research questionnaire surveys where data were coded in such a manner for quantification would allow statistical analysis. Therefore qualitative and quantitative methods were combined depending on specific analytical purposes in this research.

The main advantage of multi-methods is that it produces a more complete, holistic and contextual portrait of the object under study. Beyond that, it is useful to use qualitative approaches to build hypotheses and then take advantage of quantitative methods to test these (Ghauri, Gronhaug and Kristianslund, 1995). The demonstration of differences in emphasis between qualitative and quantitative methods in Table 3.2 underlies the advantage of *triangulation* (multi-methods approach).

Table 3.2 Difference in emphasis in qualitative versus quantitative methods

Qualitative methods	*Quantitative methods*
• Emphasis on understanding	• Emphasis on testing and verification
• Focus on understanding from respondent's or information's point of view	• Focus on facts and/or reasons of social events
• Interpretation and rational approach	• Logical and critical approach
• Observations and measurement in natural settings	• Controlled measurement
• Subjective 'insider view' and closeness to data	• Objective 'outsider view' distant from data
• Exploitative orientation	• Hypothetical-deductive; focus on hypothesis testing
• Process oriented	• Result oriented
• Holistic perspective	• Particularistic and analytical
• Generalisation by comparison of properties and contexts of individual organism	• Generalisation by population membership

Source: Reichardt and Cook (1979)

3.5.4 Data collection and sources

All the data required by the research were collected by means of searching published literature and statistical figures, interviewing machine tool associations, conducting questionnaire surveys and case studies in both the UK and China.

The existing secondary data, such as statistical figures for machine tools, were mainly collected from CMTAB and MTTA. This helped to build up a scenario regarding machine tool production, consumption, import and export as well as local market shares in both countries. However, secondary data were not sufficient for the research requirement. Key variables included in the research hypotheses such as technology transfer benefits, costs and risks, as well as technology attributes under different forms of collaboration, cannot be obtained from secondary data. The lack of significant returns from these data led to the tests of hypotheses and establishment of framework to be mainly based on the results of analysis from primary data. Primary data collection was therefore one of the major tasks and these data were substantially used for the analysis of the research questions.

Due to the importance of the primary data for the research, the data collection method was given detailed thought before investigation commenced. Primary data were gathered mainly through interviews and questionnaire surveys as well as observations. Interviews and observations were undertaken in company visits where face-to-face discussions and observations (in workshops) took place. Questions for discussion were in general semi-structured, because it could ensure that while research dimensions were focused, the insights of related context could also be explored (Fowler and Mangione, 1990; Mishler, 1986). More specifically, questions for longitudinal case studies were increasingly more structured in order to obtain a clearer picture and deeper understanding of key factors affecting the value of technology, along with the in-depth investigation process in these companies.

3.5.5 Case study

> There are times when little is known about a phenomenon, current perspectives seem inadequate because they have little empirical substantiation...In these cases theory-building from case-study research is particularly appropriate because theory-building from case-studies does not rely on previous literature or prior empirical evidence (Eisenhardt, 1989; p.548).

Intensive case studies can help to obtain the sufficient information, to explain the unique features and to point out the characteristics of a phenomenon (Eisenhardt, 1989; Selltiz *et al*, 1976). In-depth case studies have been determined to be an effective approach when investigating dynamic organisational processes such as performance evaluation (Marshall and Rossman, 1989), and in creating a theory that incorporates the participants' constructs and frameworks, rather than the researcher's (Eisenhardt, 1989). A case study was therefore a preferred method to be employed in this relatively unexplored subject where existing theory seemed inadequate to serve as a guide.

According to the investigation framework, both snapshot and longitudinal approaches were employed in the case studies. Case data have been gathered through plant visits and interviews with staff including managing directors, directors or managers in production, finance, international marketing/sales departments and chief engineers.

3.5.5.1 Case study design

There is no particular case as a critical case that can meet all the requirements necessary to a research issue (Ghauri, Gronhaug and Kristianslund, 1995). Hence, multiple case study design is more appropriate, particularly for an inductive approach but looking for general explanation (Yin, 1989). In order to avoid bias or inconclusive results from a single-perspective approach (Osland and Cavusgil, 1998), the whole case package included three groups of companies: technology suppliers (the UK and UK based machine tool companies), technology acquirers (Chinese machine tool companies) and machine tool users (Chinese user companies). The category of cases was based on the features of each group in serving a particular purpose of the study. A total of 30 machine tool companies in the UK (14) and China (16), with various technology transfer experiences, have been investigated. The users comprise 14 Chinese companies in major machine tool user sectors.

For the snapshot cases, initial interviews were supplemented by follow-up questionnaires to collect more detailed information on the specific technology arrangements and perceptions. For the longitudinal cases, sequences of more structured interviews were used to develop detailed knowledge based on previously gathered information and to establish the progress of any transfer arrangements where appropriate. The "pair" companies (includes both partners) provided an opportunity to have on-going observation showing the development of their collaborative operations. It allowed the research to identify key factors affecting the value of technology at different stages within different collaboration arrangements. Some major and critical factors identified from snapshot cases and surveys were fedback to these longitudinal case companies for further explanation so as to obtain a deeper understanding. More importantly, multiple sources of insights and perspectives helped reduce bias and threats to validity that can result from reliance on single-party informants (Osland and Cavusgil, 1998). By visiting both sides of the partnerships, differences in the perceptions and expectations between technology suppliers and acquirers were able to be identified, compared and justified. This special 'attribute' derived from 'pairs' cases would greatly help the research investigation to meet the requirements from the research question. It is because the value of technology is established within the context of specific technology transfer arrangements, where both parties' concerns are specified and considered. Therefore, 'pair' companies have been the focus in the case studies.

3.5.5.2 Case study foci

The foci of the snapshot and longitudinal case study investigations are highlighted in Tables 3.3 and 3.4 respectively.

Table 3.3 Focus in snapshot case studies

Cases of Suppliers	***Cases of Acquirers***
• Perceptions	• Expectations
• Features of production	• Features of production
• Types of strategies	• Assessment of current capacity
• Forms of transfer	• Objectives of technology collaboration
• Components of technology	• Forms of collaboration
• Determinants of owner's value	• Components of transfer value
• Importance of know-how	• Importance of value components
- innovating know-how	• Judgmental factors
- operational skills	

Table 3.4 Focus in longitudinal (pair companies) studies

Strategic	***Technical***
• Objectives of TT	• Technological capability
• Fulfilment of objectives	• Transfer contents
• Forms and phases of collaboration	• Transfer features
• Strategic position in local market	• Absorption and transfer results
Commercial	***Operational***
• Value of know how	• Interaction & coordination of financial, technical and strategic returns
• Payment arrangements	• Alteration of arrangements
• Competitiveness of end-product	• Measure to maintain effectiveness
• Degree of commercial achievement	

Data from the technology suppliers were analysed to develop a detailed structure of owner's value as well as their perception of transfer value. The focus of the investigations in technology acquirers was on transfer value.

Case studies for Chinese machine tool users were also conducted. This was to obtain the perceptions of machine tools of different origins from the users' point of view. The objectives for purchasing machines and the major concerns for selecting suppliers and products were identified. The view on the key issue to the user linked to the value of technology, i.e. quality/performance to price ratio, were obtained. The users' satisfactions with Chinese and foreign machine tools against their expectations were also assessed.

3.5.5.3 Lists of case companies

The Chinese and UK machine tool case companies are shown in Tables 3.5 and 3.6.

Table 3.5 Chinese machine tool case companies

Company Name	Major products	Foreign TT partner's origins	Interviewees
1. Beijing Machinery & Electricity Institute	• CNC machining centres	UK Japan Germany USA	President, Vice President
2. Beijing No.1 Machine Tool Works	• Millers • Gantry millers • Machining centres	Germany Japan USA	Chief Engineer
3. Beijing No. 2 Machine Tool Works	• Grinders • Machining centres • Boring machines	Japan Italy USA	Vice Director
4. Shanghai No.1 Machine Tool Works	• Gear processing machines • Production lines	UK Germany Italy	Deputy Chief Engineer, Director of R&D Institute
5. Shanghai Machine Tool Company Ltd	• Precision grinders • Crankshaft grinders	USA	Chief Engineer
6. Changzheng Machine Works	• Millers • Machining centres	UK US	President, Vice President, Chief Engineer etc.
7. Ning Jiang Machine Tool Works	• Precision machine tools	UK	Vice Director & Chief Engineer
8. Chongqing Machine Tool Works	• Gear hobbers • Gear shavers	France	Deputy Chief Accountant
9. Tianjin No.1 Machine Tool Works	• Gear shapers • Machining centres • Precision power transmission appliances	Germany Japan US Sweden	Director Chief Engineer
10.Tianjin Metalforming Machine Tool Works	• Hydraulic presses • Large capacity press	Japan Germany	Director Senior Engineer
11.Shenyang No.1 Machine Tool works	• Vertical & horizontal lathes • CNC turning centres	Japan US Germany	Vice Director Deputy Chief Engineer
12.Shenyang Metalforming Machine Tool Works	• Shears • Hydraulic press breakers • De-coiling, flattening & shearing lines	Italy Korea	Director Chief Engineer
13.Changzhi Metalforming Machine Tool Works	• Plate benders	UK Japan Germany Korea	Director Manager of Imp & Exp Department
14.Jinan No.1 Machine Tool Works	• Precision lathes • Machining centres	Japan Germany US	President
15.Changzheng-Bridgeport Machine Tool Ltd (JV)	• CNC machining centres	UK	General Manager Vice General Manager
16.Changcheng Machine Tool Works	• Copying lathe • CNC lathes • Copying lathes	Italy UK	Chief Engineer Manager of Marketing Dept.

Table 3.6 UK & UK based machine tool case companies

Company Name	Major products	Business in China	Interviewees
1. Cincinnati Milacron UK Ltd	• CNC vertical machining centres • CNC turning centres	Co-production Joint venture Selling machines	Director of Business Development, Director of Marketing etc.
2. Bridgeport Machines UK Ltd	• CNC vertical machining centres • CNC horizontal machining centres	Joint venture Selling machines	Managing Director, Manufacturing Director, Sales Manager etc.
3. Addison Tube Forming Ltd	• CNC tube benders	Phased licensing agreement Selling machines	Managing Director, Sales Director
4. Giddings & Lewis UK	• Automatic transfer lines	Licensing agreement Selling machines	Sales Manager
5. BSA Tools Ltd	• CNC automatic machining centres • CNC turning centres	Subcontracting Co-production Selling machines	Managing Director Sales Director Chief Engineer
6. The 600 Lathes	• CNC lathes • Conventional lathes	Selling machines Seeking collaboration partner	Product Strategy & Marketing Director
1. Matrix Grinding Technologies Ltd	• CNC grinding machines	Selling machines Seeking collaboration partner	Export Sales Manager
2. Jones & Shipman	• CNC grinding machines • CNC honing machines	Selling machines	Sales Director
3. Control Techniques Ltd	• CNC controller and drives	Selling products Seeking collaboration partner	Managing Director-East Asia
4. Heller UK Ltd	• CNC machining centres	Selling machines via Headquarters	Production Manager
5. Landis Lund UK	• CNC crankshaft grinders • CNC camshaft grinders	Selling machines	International Sales Manager
6. Asquith Butler	• CNC gantry machining centres	Selling machines	Sales Director
7. LK Ltd	• 3 Co-ordinate measuring machines	Selling machines	Sales Director Sales Engineer
8. Renishaw Plc	• CMM probe systems • Machine tool probe systems • Calibration products	Selling products	Marketing Service Manager

The user companies are mainly in engineering, machinery, electronics and automotive sectors. These sectors are major machine tool users in China. They have in general been involved in relatively more machine tool imports and hence have more experience of using machines from different origins. In total, 14 companies were visited (see Table 3.7).

Table 3.7 Chinese machine tool user case companies

Company Name	Company Status	Major Products	Interviewee
1. Beijing Jeep Corporation Ltd	Sino-American Joint venture	Jeeps	Chief Project Engineer
2. Beijing Tianwei Fuel Injection Equipment Inc.	Sino-American Joint venture	Injectors	Chief Process Engineer
3. Kangsen-Armstrong	Sino-American Joint venture	Pressure reducing valves	Production Manager
4. Shanghai Aircraft manufacturing factory	State-owned	Aircraft	General Engineer, Chief Economist
5. Wuxi Wandi Power Engineering Group	Limited company	Diesel engines	Deputy General Engineer
6. Wuxi Holset Ltd	Sino-British Joint venture	Turbochargers	Chief Technician
7. Wuxi Walta company Ltd	Sino-German Joint venture	Cutting tools	Production Manager
8. Hong Ming Electronics Industry General Company Mould Centre	State-owned	Electronic moulds	Director, Chief Economist
9. Sichuan Gear Works	State-owned	Engineering & auto gear boxes	Director
10. Chengdu Electronic Mould Centre Company Ltd	Sino-German Joint venture	Electronic moulds	General Manager
11. Tianjin Auto Die and Mould Works	State-owned	Automotive moulds	Chief Project Engineer
12. Capital Steel Machinery Centre	State-owned	Steel making machines	Deputy Chief Engineer, Deputy Institute Director
13. Tianjin Sibtex Electric Submersible Pump Ltd.	Sino-American Joint venture	Submersible pumps	Sales Director
14. Tianjin SM - Cyclo Co. Ltd	Japanese wholly-owned company	Electrical drives	Section Chief (Engineer)

3.5.6 Questionnaire surveys

Apart from the case studies, questionnaire surveys also played a very important role in the research investigations. Case studies provide rich and detailed insights of how technology was actually valued while questionnaire surveys offer opinions and perceptions from a more extensive basis. Two of the main benefits of questionnaire surveys were that bias which may exist in a particular individual case could be distinguished and the main factors that affect technology valuation could be ascertained. Altogether three questionnaire surveys were carried out:

i) A survey of UK (and UK based) machine tool companies who have transferred, or are going to transfer, technology to China or sell machines in China.
ii) A survey of Chinese machine tool manufacturers covering most of the key enterprises who have imported, or plan to import, technology through various forms of collaboration.
iii) A survey in China of companies in the engineering, machinery and automotive sectors where both Chinese and foreign machine tools are used.

3.5.6.1 Questionnaire design

The two questionnaires for machine tool manufacturers in both the UK and China were designed as a 'pair'. As the criteria used in the evaluation process would affect satisfaction with the result (Osland and Cavusgil, 1998), identical questions relating to common factors that require both suppliers' and acquirers' considerations were included with consistency in both questionnaires, so that their assessments of factors could be compared. The specific factors, for which each side might have different concerns, were also questioned in an equivalent way so that the major divergence between the supplier and acquirer on the value of technology could be identified. The user survey was complementary to the manufacturers' surveys. Similar questions, for example, about technology gaps and attributes, were asked to obtain users' perceptions and assessments. Users' satisfaction against their expectations on the quality and performance of machines from different origins were also acquired through ranking questions. In some aspects, the users' survey was designed as a useful justification to the manufacturers' surveys in terms of their assessments of the quality and performance of their machines, etc.

More specifically, the UK machine tool manufacturers survey mainly focused on the perceptions and assessments of factors affecting the owner's value of technology. The survey of Chinese machine tool companies specifically investigated their opinions on transfer value to find what were of most concern for technology valuation from the acquirers' point of view. The user's survey was to establish current involvement in using machines built with foreign and Chinese technologies. Based on such experiences, their perceptions and assessments of the performance of machines from different origins were explored, and their objectives underlying users' influences on the transfer value were also studied.

The overall questionnaire design for machine tool manufacturers and users served the following purposes:

- Within each questionnaire the following data were acquired:

- distribution of opinions
- demonstration of technology transfer experiences
- assessments of transfer results based on the experiences
- implications for technology valuation

- For comparative purposes between the three questionnaires further analytical data were gained as follows:

  - similarities and differences in transfer objectives
  - similarities and differences in opinions on technology attributes
  - similarities and differences in opinions on contributory factors for value generation
  - similarities and differences in opinions on suitability of collaboration
  - influences in technology valuation from users
  - implications for technology valuation.

3.5.6.2 Scaling and rating

All the questionnaires were designed as a combination of both descriptive and analytical features. Replies to descriptive questions provided details of technology transfer experiences for the purpose of phenomena identification. Answers to analytical questions provided the perceptions and assessments on technology value as well as transfer results for the purpose of research analysis. Measurement was considered when analytical questions were designed. Some non-numerical factors such as technology attributes were coded by defining categories and assigning a number to each category. These numbers were given meaning for scaling and rating which enable the use of statistical techniques for further assessment.

The Likert scale (Mckennell, 1977; McDowell and Newell, 1987; Phillips, 1976) was used as the main scale procedure in questionnaires. The use of Likert scales removes the disadvantage of attempting to gauge opinion with a single question by providing a format whereby answers are formed into scales (Ghauri, Gronhaug and Kristianslund, 1995). To ensure the validity of the scale, content validity was used to assess whether a comprehensive coverage (of items) was provided for each question. All the items were specifically discussed and modified accordingly with some machine tool companies as well as machine tool experts in China.

In the questionnaires, Likert scales were used specifically to assess the importance of transfer objectives, contributory factors, suitability of transfer arrangements and satisfaction of transfer results. These were identified in case studies as the key factors in influencing the value of technology. Measures were set on *five-point* Likert-type scales (scores between 2-6 in ranking) but extended to a point (score of 1) to distinguish the irrelevant situation or extreme case (see Table 3.8). To measure transfer objectives, contributory factors, transfer arrangements and transfer results, the degree of 'importance', 'suitability' and 'satisfaction' were scaled with scores between 1 - 6. Table 3.8 shows the meaning of scores in each measure.

Table 3.8 The meaning of the scales

Score	Meaning		
	Importance	**Suitability**	**Satisfaction**
6	*Imperative*	*Most suitable*	*Fully satisfied*
5	*Very important*	*Very suitable*	*Very satisfied*
4	*Important*	*Suitable*	*Satisfied*
3	*Fairly important*	*Fairly suitable*	*Fairly satisfied*
2	*Not very important*	*Not very suitable*	*Not very satisfied*
1	*Irrelevant*	*Unsuitable/not the case*	*No satisfaction*

For technology attributes, the perceived differences between foreign technology based (including foreign made and Chinese made) and Chinese technology based machine tools were also established. The rating of the attributes was scaled with a score of 10 meaning *completely satisfied* and a score of 1 meaning *not at all satisfied*, with scores in between referring to varying degrees of satisfaction.

3.5.6.3 Sampling consideration

The size of sample was considered in relation to the research question. In order to acquire the comprehensive perceptions which can represent the majority opinions in the machine tool sector, the questionnaire surveys for machine tool manufacturers both in the UK and China were meant to cover a relatively large population in the specified category. Also the respondents included companies who either have already had technology transfer experiences or have not yet had experiences. Table 3.9 shows the sizes of each questionnaire survey within the targeted categories.

Table 3.9 Surveys for machine tool companies in both China and UK

	Chinese Survey	*UK Survey*
No. of key Chinese m/c tool Cos.	100	-
No. of UK m/c tool Cos. who have TT* or sales to China	-	34
No. of questionnaires sent	100	34
No. of respondents	58	11
No. of TT experienced companies	49	5
No. of TT experience-details provided	79	5

Note:* technology transfer

For the Chinese machine tool manufacturer survey, 58 Chinese machine tool companies responded to the survey, a response rate of 58% among the key Chinese machine tool companies. Altogether 79 cases of technology transfer from foreign companies were detailed in the responses from these companies.

The UK survey received 11 responses, a response rate of 30% from the total of 34 UK machine tool and component companies who have business links to China. Despite the lower receiving rate, however, the participants covered nearly all the UK machine tool manufacturers who have transferred technology into China, according to the MTTA's membership.

The user survey has a relatively small sample but focuses on the major machine tool user industries in China. There were 30 Chinese machine tool user participants in this survey. A total of 98 experiences of purchasing and using machines from different origins were provided with details from the survey (see Table 3.10).

Table 3.10 China machine tool user survey: sectors and experiences

Sectors	Number of companies	Experiences of using machine tools from different origin: Foreign machines	Chinese made machines on TT basis	Chinese machines
Machinery equipment	7	10	9	8
Automotive	5	8	5	4
Electronics	7	9	6	7
Engineering	9	13	6	9
Others	2	-	-	4
Total	30	40	26	32

3.5.7 Analytical tools

This study employed both qualitative and quantitative techniques for data analysis. The purpose of qualitative analysis was to define and identify the nature and characteristics of technology valuation, as well as assess and justify the influences of major factors which are closely associated with the issue. The use of case studies was a primary tool for qualitative analysis.

On the other hand, the aim of the quantitative analysis was in general to establish relationships between related factors by testing their interactions and impacts on the value. There were three main objectives in using quantitative analysis in this study:

i) to test the significance of the findings drawn from questionnaire surveys;
ii) to test the correlation between related variables; and
iii) to test the impact of independent variables on dependent variables.

The *Chi square test of goodness of fit* was used for the test of significance for one variable. It is to examine whether data were derived from a truly random sample. The test was particularly used for the assessments made in the questionnaire surveys on factor importance and result satisfaction. The *Chi square test of independence* was used to test the dependence in the assessments involved in more than one variable. The significance level[3] of these distributions was tested in order to establish confidence for the generalisations made from these empirical findings.

The Pearson's coefficient of correlation (r)[4] and *coefficient of determination* (r^2) were calculated to test the correlation between associated variables. Then the *F test* was used to test the significance level of the correlation. This test was specifically for the related factors which may have a 'cause and effect' relationship so that the reasons behind transfer results can be revealed.

A comprehensive statistical method, *seemingly unrelated regression*[5] (SUR, also called *multivariate regression* or *Zellner's method*) was used for establishing the prediction, explicitly, of the extent to which the dependent variables are affected by independent variables. This tool particularly meets the requirement for measuring the attributes of technology and collaboration in contributing to the value of technology.

It should be noted however, despite SUR being used for measuring the extent to which the dependent variables are affected by independent variables, the study has no intention to draw a conclusion of any numerical relationship between related variables from these numbers. Rather, the conclusion to be drawn from the quantitative analysis was the existence of these relationships and the importance of their impacts on technology valuation so that the research hypotheses can be tested and proved. The generic and meaningful results, in either theoretical or practical terms, from quantitative analysis are the identification and establishment of relationships between the related factors in the process of technology valuation. The results in the form of numbers from the SUR analysis only indicated a prediction under specific circumstances, however, the significance was not to conclude there is such a degree (or

[3] The value of χ^2 is found from the formula: $\chi^2 = \Sigma\,(O-E)^2 \div E$. Where O = observed value of variable and E = expected variable.

[4] The formula to compute *r* is as follows: $r = \Sigma(X-\overline{X})(Y-\overline{Y}) \div \sqrt{\Sigma(X-\overline{X})^2(Y-\overline{Y})^2}$. Where r = coefficient of correlation. $\overline{X}$= mean of the independent variable. $\overline{Y}$ = mean of the dependent variable.

[5] The estimation equation in general takes a form as follows: dependent variable = Σ [coefficient *1* x variable *1* + coefficient *2* x variable *2* + ... coefficient *n* x variable *n*].

magnitude) of specific impacts but the confirmation of the relationships which would be essentially required for developing a technology valuation framework.

Tables 3.11 and 3.12 provide the results of *Chi Square* significance test for the tables that would require such a test as appropriate in the thesis. The data which were tested were collected from the three questionnaire surveys. The results of correlation and SUR tests for the specific purpose are shown in different chapters as appropriate.

Table 3.11 The *Chi Square* significance test of the normal distribution of the random variables.

Tables & Figures	***Variables***	***Survey resources***	***Significance***
4.1	Averaged cost structure to produce a CNC machine tool	UK m/c	0.0158
4.2	Importance of major factors in determining value	UK m/c	0.045
4.3	Importance of transfer benefits	UK m/c	0.052
	Degree of satisfaction with actual results		n/s
4.4	Assessment of technical, market and collaborative risks	UK m/c	n/s
4.5	Average satisfaction of the result of the end-product quality	UK m/c	n/s
5.1	Expected price differences between equivalent general m/cs	UK m/c	n/s
	Expected price differences between equivalent general m/cs	CH m/c	0.000051
	Expected price differences between equivalent general m/cs	CH user	0.109
	Expected price differences between equivalent special m/cs	UK m/c	n/s
	Expected price differences between equivalent special m/cs	CH m/c	0.000425
	Expected price differences between equivalent special m/cs	CH user	0.0159
Fig 5.4	Importance rating of know-how and skills	CH m/c	2.27E-08
	Assessment of the current situation		1.59E-07
5.7	Satisfaction of results of technological improvement	CH m/c	7.8E-8
5.9	Importance of major attributes for increasing exports	CH m/c	*1.53E-06*
5.10	Importance of factors in influencing selection of suppliers	CH user	2.62E-08
5.12	Assessment of the strategic importance of know-how and skills	UK m/c	n/s
5.13	Structure of the overall acquisition costs (average)	CH m/c	2.16E-13
5.14	Time taken in technology transfer experiences (average)	CH m/c	1.09E-53
5.15	Assessment of technical, market and collaborative risks	CH m/c	*0.000017*
6.1	Suitability of terms of payment at different contract price	CH m/c	n/s

Continued

Tables & Figures	*Variables*	*Survey resources*	*Significance*
6.3	Priority given to different terms of payment	UK m/c	n/s
	Priority given to different terms of payment	CH m/c	2.06E-12
6.5	Importance of technical requirements in technology transfer	CH m/c	2.73E-15
6.6	Importance of technical factors in determining partner	UK m/c	n/s
6.7	Importance of achievement in enhancing the strategic position	UK m/c	0.04
6.8	Importance of achievement in the strategic development	CH m/c	1.38E-15
6.9	Importance of terms of transfer payment determining factors	UK m/c	0.04
6.10	Satisfaction with the results in different transfer arrangements	CH m/c	n/s
6.12	Suitability of forms of transfer arrangements	CH m/c	1.74E-07
	Suitability of forms of transfer arrangements	UK m/c	n/s
8.2	Importance of objectives for technology transfer	CH m/c	0.000142
	Importance of objectives for technology transfer	UK m/c	0.03
8.3	Importance of contributory factors for capability development	CH m/c	1.54E-24
8.4	Product features performance between different general m/cs	CH user	n/s
	Product features performance between different special m/cs	CH user	n/s
8.5	Importance of attributes in contribution to improving quality	UK m/c	0.04
	Assessment of actual obtained technology attribute		n/s

Survey sources: UK machine tool companies (UK m/c), Chinese machine tool companies (CH m/c) and Chinese machine tool users (CH user).

The significance at/less than 0.01 level means the random variables are normally distributed. Many results from the UK survey did not appear to be statistically significant at this level (regarded as n/s i.e. not significant) due to the small number of participants and limited valid responses to a specific question.

Table 3.12 The *Chi square* significance test of independence of variables (assessments of variables between machines from different origins)

Table & Figures	***Variables***	***Survey resources***	***Significance***
5.2 and Fig 5.3	Comparison of product feature performance between different origins of machine tools	CH m/c	
	Assessment of ease of use and maintenance		0.02394
	Assessment of functionality		5.77E -10
	Assessment of reliability		7.4E -18
	Assessment of accuracy		3.04E -13
	Assessment of consistency		5.13E -15
	Assessment of processing productivity		1.95E -12
	Assessment of appearance		1.37E -18
5.6	Contributions to realising objectives by using machines from different origins	CH user	
	- To improve quality consistency		0.0001
	- To produce higher quality products		0.0003
	- To reduce processing time		0.0009
	- To increase production capacity		0.063
	- To produce new products		0.0014
	- To meet customers' specific requirements		0.097
	- To reduce manufacturing cost		0.12
5.10	Satisfaction of suppliers' factors from using machines from different origins	CH user	
	- Advanced technological know how		0.00004
	- Ability to customise machines		0.08
	- Quality registration		0.02
	- Reputation among your industry		n/s

Table 3.12 shows that the majority of results was statistically significant. It indicates that most of the participants' assessments of each variable were independently made against the rating criteria.

3.6 Validity and reliability considerations

Research that focuses on collaborative issues but is not grounded in the context of multiple perspectives may lack construct validity (Kerlinger, 1986) and/or contextual relevance

(Bonoma, 1985). The rationale of triangulation was therefore considered and, as mentioned above, there are several research methods being used in data collection. The specific purpose of using triangulation was to capture the multiple 'voices', and therefore truths, that exist in relation to any phenomenon. The validity of a measure can then be examined by testing convergence with expectation derived from various knowledge about the subject matter, as well as to discriminate between different concepts (Campbell, 1959; Campbell and Stanley, 1966; Carmines and Zeller, 1979; Sullivan and Feldman 1979). For example, the internal validity, (i.e. whether the result/cause-effect relationship obtained within the study is true), can be derived from longitudinal case studies and 'pair case' comparisons where 'multiple-party' investigations were conducted and responses from both partners were elicited so that potential misleading findings were avoided (Osland and Cavusgil, 1998). The external validity (i.e. whether the finding can be generalised) was proceeded through relatively extensive and holistic questionnaire surveys of suppliers, acquirers and users, as well as the research secondment[6] in which the major research outputs were tested or further explored. The results were, as stated, "cases which confirm emergent relationships enhance confidence in the validity of the relationships. Cases which disconfirm the relationships...provide an opportunity to refine and extend the theory" (Eisenhardt, 1989).

Control over the validity of indicators varies with the degree to which researchers are involved in collecting data (Lewis-Beck, 1994). Where researchers can design the measures being used in their studies, considerable control over validity is obtained in terms of convergence and discrimination; both are also required for reliability. In this research, reliability was, on the one hand, pursued through recognition of the need for consistency of meaning of concept and terms in questions. On the other hand, the replication of answers from multi-method investigation also contributed towards reliability. The major measures being used in this study were specifically designed according to the requirement of the research question - technology valuation. They were, however, clarified during the interviews with case companies. Key issues identified from the questionnaire surveys were also fedback to the longitudinal case studies in order to obtain a deeper understanding. To avoid selection bias, case companies included those with and without experience of technology transfer. Moreover, within the experienced companies, successful and unsuccessful experiences as well as variation in

[6] The author acted as the research secondment between March 1998-1999, and since then as the international project development manager, working in BSA Tools Ltd to co-ordinate its technology collaboration with China.

different stages of transfer process were also contained. The intention was to capture viewpoints under different circumstances so that a judgement could be made on a holistic ground.

3.7 Linkage Between Research Issue And Methodology

Based on the research issue - technology valuation - two hypotheses were proposed. Hypothesis 1 underlined the impacts of *quality* of technology, i.e. the contribution to the enhancement of capability, on its value. Given the quality of technology, hypothesis 2 assumed that the value would differ depending on the effectiveness of its use in the process of generating and capturing future returns. These two broad questions comprised the following detailed subheadings related to the valuation:

(i) Quality of technology
- technology gap
- technical strength/attributes
- user's needs and perceptions
- implications for market competitiveness/commercial success

(ii) Effectiveness of use
- transfer objectives
- transfer arrangements
- sharing arrangement of benefits, costs and risks
- operational measure to maintain effective collaboration
- implications for value generation and realisation.

Referring to sections 3.5.5 and 3.5.6, it can be seen that all the above aspects were thoroughly covered by the contents in the questionnaire surveys and case studies. It followed that, while questionnaire surveys provided codified data for quantitative analysis, case studies, longitudinal cases in particular, offered explicit causes behind the effects for qualitative assessment. The research question and methodology being employed, including investigation methods and analytic methods, were all closely linked. As a result, the hypotheses can be tested based on the evidence drawn from the research investigation. The technology valuation framework was therefore established on solid ground.

So far the background of the research, literature overview and research methodology have been outlined. From these a more detailed study will follow. The next chapter presents the results of analysis on the factors affecting the owner's value from technology supplier's perspectives.

CHAPTER FOUR
FACTORS AFFECTING THE OWNER'S VALUE

4.1 Introduction

For the owner, technology is a key part of the organisational knowledge which gives the company distinctive capabilities and competitive advantages (Porter, 1979 and 1980). The advantages and effectiveness of technology are dependent on the activities of how technology is created (technology software) and produced (technology hardware). The return on R&D investment and control of such competitive resources always raise a concern to the owner of the value of technology when transfer is taken place (Casson, 1987; Teece, 1982). Further, as the sharing of technology with others may create a joint advantages (Bailetti and Callahan, 1993) or use the assets better (Dunning, 1981), the value (of technology) would also be added in the externalised downstream activities (Kodama, 1992; Porter, 1986).

The added value from using external resources in the downstream activities is important to the owner, particularly when the achievement of future generated value is more strategically significant than the realisation of immediate commercial benefits. For example, when the owner seeks to maximise its technology benefits by extracting additional value through developing access to a new or expanding market and exploiting local advantages. However, the future return from such activities would not arrive instantly and may not even be achieved. In such a situation, how would the owner assess and compare the assured immediate benefit and uncertain future return is a vital question for technology valuation. Should the owner give priority to capturing short-term benefit or seek to achieve long-term development? No matter what the owner chooses, both the current worth of technology generated upstream and the future value added downstream need to be considered. The implication for the owner is that the value of technology is not its selling price, rather, it is the gain including the parts of added value both upstream and downstream that they can capture.

From the owner's point of view, the owner's value is a primary value component as it comprises the basic elements of current value of technology. However, because it only embraces the aggregate value generated upstream, it does not necessarily reflect all the gains that the owner intends to capture. The future value may come from transfer value (for example, where a royalty is to be paid or a share of benefits can be gained in return for the use of the technology by the acquirer) which will be further discussed in Chapter 5. This chapter focuses on the identification and assessment of the major factors that the owners of technology may consider in determining the owner's value.

4.2 Cost Structure and Element Importance in The Owner's Value

As discussed in Chapter 3 of the value concept, the owner's value is fundamentally based on the cost at which technology is generated. It includes its development, production and distribution costs together with the cumulative costs of any other upstream activities and opportunity cost considerations. It will add transfer cost if technology is being transferred, as well as the notional profit that the owner wishes to gain for transferring the technology for others to use (Bennett *et al*, 1997b).

Very often, cost is the focus of 'conflict' in perceptions of value between the owner and acquirer. On the one hand, cost is mostly the concern of the owner and needs to be covered in the value when technology is being transferred. On the other hand, the owner's cost of the technology is of a high commercial confidentiality hence, without exception, not disclosed to, and therefore not at least fully appreciated by, acquirers.

If selling a machine tool as a product rather than a means of transfer of technology, the cost determination may be more straightforward, regardless of market competition for the same products. Table 4.1 shows an average cost structure to produce a CNC machine in the UK machine tool companies. In the cost breakdown the only 'questionable' element is development cost as the owner needs to decide how to amortise the total development cost in each machine in order to maintain price competitiveness.

Table 4.1 Averaged cost structure to produce a CNC machine tool

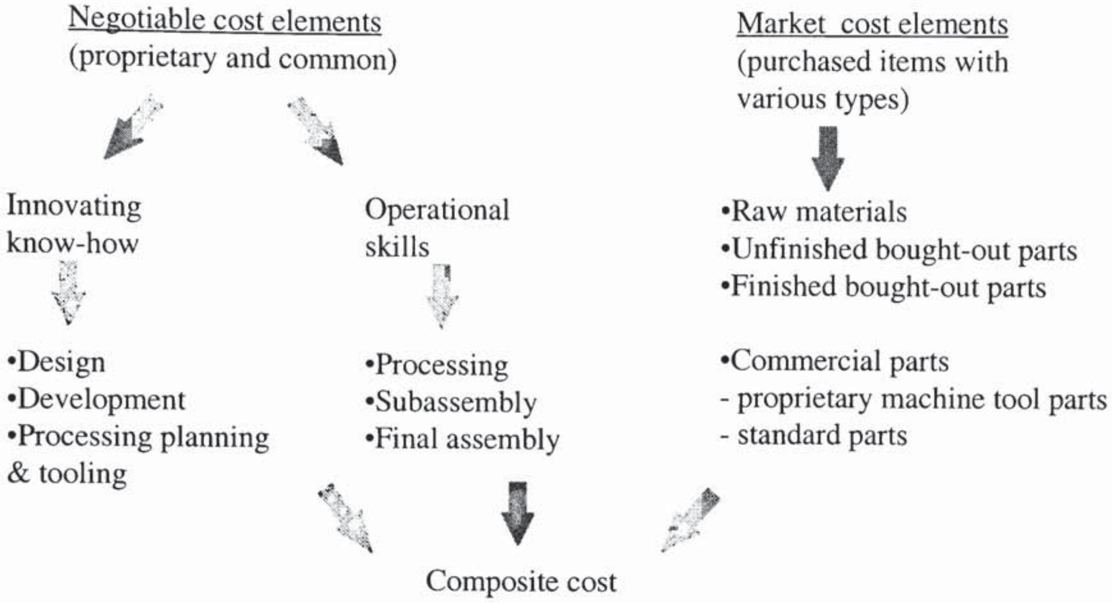
Cost breakdown	Percentage in total	
• Product development cost	6%	
• Production cost	69%	
of which - labour cost		18%
- material cost		51%
• Overheads	16%	
• Distribution cost	9%	
Total costs	100%	

Source: The UK machine tool survey

However, the cost determination in valuing technology is not as simple as the cost of the product. The owner often feels that it is hard to determine the cost level despite its knowledge of all the cost elements of technology, since in the cost structure of technology there are some elements that cannot be easily quantified but are of vital importance to the owner of technology. The question arises from the difference between the value of technology and the cost of the product, as the product is made to satisfy the customer's needs while technology is developed to produce benefits for the owner. If technology is transferred it means the owner would lose, or share with others, the resource from which expected benefits are created. The owner therefore needs to ensure that the value of technology comprises all its expected benefits from the technology. Further, considering the competitive importance and strategic implications of technology to the owner, it makes the question of value even more complex.

In order to examine the owner's value, a cost structure of technology rather than that of the product should be developed. The difference is that the former shows the nature of the cost elements and their implications for the owner's value while the latter only indicates how the costs of a product are structured in proportion, as shown in Table 4.1. Figure 4.1 presents a model of the cost structure of machine tool technology based on the analysis of specific products in UK companies. The model has been validated with assistance from the collaborating companies of the project.

Figure 4.1 The cost structure of owner's value



The model indicates that from the owner's perspective costs of the technology can be further separated into two types. First, there are some costs incurred externally through bought-out parts, materials and commercial parts. Market prices for commercial parts are normally well established so their influence upon the cost of technology product is known. Although for bought-out parts it requires the owner to provide know-how in the form of drawings and specifications, these costs normally have market prices as references so are more easily determined. Second, there are those costs that are incurred internally by virtue of the fact that they are linked with the owner's 'proprietary' activities. These costs are more difficult to measure because many of them are in the form of know-how and skills. More specifically, some of these know-how and skills are proprietary types which often reflect the core of the owner's technical competence. Furthermore, know-how and skills, according to their features, can also be categorised into two types so as to assess the cost element that affect the owner's value more explicitly:

i) Innovating types such as design, development, process planning and tooling know-how.
ii) Operational types such as processing, sub-assembling and final assembly skills.

The innovating components are the 'key' to creating new ideas, improving and updating technological capability while the operational elements are more of the experience-based expertise and skills to assist in ensuring high reliability and accuracy of product, as well as the improvement of working efficiency. Owners would normally consider an innovating know-how to be more strategically important than an operational skill hence, if the owner wishes to protect a technological advantage, the emphasis will be on transferring operational capabilities only.

If the key technology is to be transferred then the value will need to reflect the owner's intellectual investment in development together with an adequate return. Further, since owners tend to internalise control over proprietary know-how as their critical benefit generating resources (Young and Lan, 1997), when the proprietary innovating know-how is transferred, the owner of technology would consider an even higher rate of investment return to be included in the value. From the owner's point of view, the use of such know-how would enable the acquirer to gain more benefits so the value of technology ought to be greater on the one hand, while also reducing the scale of return to the owner for letting others share its technological advantage on the other. All these influences caused by transfer of this type of know-how in potential benefits need to be reflected in the owner's value.

Such know-how and skills are negotiable cost elements in the structure of the owner's value. In practice they are likely to be the central problematic part where there are often different perceptions of the value of technology between the owner and acquirer. Acquirers may use the owner's reputation, technological level of product and features of technology as references to judge the owner's value (e.g. see case E in Chapter 7). Nevertheless, still in question was how to measure such know-how and the skills needed in order to determine the owner's value.

4.3 Transfer Benefit Implications: Beyond Cost Calculation

Although cost provides a basis for the owner's value, there are some other factors which are also important in influencing the value of technology. Generating and capturing greater benefits is the primary motivation for technology transfer (Glinow, Schnepp and Bhambri, 1991). The owners would not transfer their competitive technology to others unless the externalised collaborative operation could enable them to gain greater return (Dunning, 1991).

The market is the source of financial return and transfer of technology has been identified as one of the most effective means for foreign companies to gain access to a market (Zhao *et al*, 1996). However, when it is difficult, due to heavy competition, to gain a market entry, foreign companies may need to reconsider the value of their technology being transferred in order to acquire the market entry. They may need to compromise the normal cost-based calculation and use a strategic valuation instead in order to capture the market potential. In such circumstances the owner's value may appear to be well away from the cost calculation and the value of technology may be realised through an alternative means. The following snapshot case study demonstrated such an example:

Case study: Haihe Metal Forming Machine Tool General Works (HMFGW).

HMFGW is one of the largest hydraulic press factories in China and maintains a large domestic market share. It has established a co-production agreement with AMO (a Japanese press manufacturer) in which HMFGW paid nothing for the drawings and know-how to produce AMO's products. It was required, however, to purchase parts from AMO.

To HMFGW the benefits from this arrangement were that it has quickly acquired the capability of producing a world standard press machine which, in the longer term, increases the possibility of selling into the world markets. To AMO, although no charge was made for the technology, nor any royalty payments either, there were three major benefits as follows:

i) The supply (sale) of key components (such as electronic parts) to HMFGW for making AMO's press machines.

ii) Good access to local potential customers through HMFGW's large market presence in China.

iii) Improvement of product compatibility to local market requirements through jointly-made modifications for the product.

In this case the technology was supplied free of charge so the owner's (AMO's) value of the transferred technology appeared to be zero. The benefits to the owner were not represented by a royalty payment, instead it was facilitated through the purchase of components together with the value placed on access to the Chinese market. The transfer benefits to the acquirer (HMFGW) was the potential technological advantage over its competitors in China from using AMO's technology (drawings) as well as the perceived opportunities in the world market.

This case demonstrated that the price charged by the supplier could be below the cost of the technology. It implies that the determination of the owner's value may be in some cases beyond the cost and price calculation. The potential gains need to be weighted and compared with the cost calculation. Cost of technology may not be necessarily covered by the owner's value if it helps the owner to capture greater future benefits. Further, the potential benefits need to be assessed which should not be only in financial terms but also in technical and strategic aspects.

Table 4.2 shows a result of the owner's assessment of the importance of major factors in determining the owner's value of transferred technology.

Table 4.2 Assessment of the importance of major factors in determining the value of technology to be transferred

Technology value determining factors	Importance
Strategic importance to the owner of the technology (proprietary)	5.22
Worldwide reputation of the owner's technology/product	4.67
Content of technology transfer package (part or whole technology)	4.33
Costs of producing the technology	3.78
Applications of technology for partner to use (general or specialise)	3.78
Availability of competing technology in markets	3.67

Source: The UK machine tool survey

It can be seen that in general the 'quality' of the technology was mostly concerned with the technology valuation by the owner. The strategic importance of the owner's proprietary know-how was placed with the highest weighting in determining the owner's value. The owner's reputation and the distinctive features of its technology were also considered as important value elements. The effectiveness of technology was represented by what know-how and skills were to be transferred and the scope or extent to which acquirers can apply the transferred technology. Table 4.2 shows that cost of producing the technology was rated between *important* and *fairly important* (for the meaning of scores refer to Table 3.8). The assessment provides a consistent result with the finding from the above case study (HMFGW). It indicates that the determination of the owner's value is not a simple cost calculation and further implies that the 'quality factors' of technology and their implications for transfer benefits to the owner may have more influence in determining the owner's value.

4.4 Transfer Risks

Many studies have found that the owners of technology would not wish to transfer their core knowledge and capabilities which are crucial to their own competitive advantage unless the benefits of making the transfer exceed the costs (e.g. Barney, 1986; Buckley and Casson, 1988; Casson, 1987; Rugman, 1986; Teece, 1982). Furthermore, since transfer benefits are generated and realised in the future through on-going processes (regardless of one-off transfer of technology) there is always an uncertainty on commercial, technical and collaborative success. Concerning the current situation in China, for example, those uncertainties may arise because:

- many local companies currently used equipment with poor reliability and traditional processes with a low degree of automation not in line with Western production methods (Hendryx, 1986);
- the problem of protecting the supplier's proprietary know-how exists in most of the technology transactions (Wolff, 1989; McElligott, 1995);
- marketing knowledge is inadequate and customer-marketing orientation has not been widely accepted (Chan *et al*, 1993);
- task uncertainty (relating to the skills and resources required) and the sequencing of tasks (Killing, 1988; Bailetti and Callahan, 1993) and co-ordination problem (identifying common objects that link task groups together) (Malone and Crowston, 1991) were often encountered in collaborations; and

- in addition, foreign companies (technology suppliers) may be even exposed to a greater risk in collaborative ventures relative to their respective contributions (O'Connor and Chalos, 1999).

All these suggest that technology suppliers will have to bear risks in their activities of seeking future benefits through technology collaborations.

Comparing the actual results in the experiences of surveyed UK machine tool companies with their expectations, Table 4.3 indicates that there is a risk in terms of achieving the expected transfer benefits with full satisfaction. The relative importance of the benefits that suppliers seek from technology transfer provide a reference point in judging the weight of each benefit in the suppliers' target.

Table 4.3 Assessment of the importance of transfer benefits and the actual results from UK companies' previous transfer experiences compared with expectations

Suppliers' expected transfer benefits	Importance of transfer benefits	Degree of satisfaction with actual results
Market entry or increased sales	5.30	44%
Enhancement of strategic position locally	5.00	50%
Reduction in production costs	4.40	28%
Meeting local customers' requirements	4.20	39%
Improvement of after-sale service	4.10	50%
Acquisition of low cost local components	3.40	28%

Source: The UK machine tool survey

Table 4.3, in general, reflects the fact that actual achievement of the suppliers' expected transfer benefits was not satisfied compared with suppliers' expectations. The results of cost reduction, as the third most important benefit from transferring technology, were least satisfied. Even for the first two most important benefits, i.e. *increased market sales* and *enhancement of strategic position,* as the major elements of suppliers' financial and strategic targets, no more than a 50% degree of satisfaction was given in the suppliers' assessment of the actual results. It implies that there is a considerable degree of benefit that may not be assured. The reason behind it was there were poor results in many aspects which would affect the achievement of overall transfer benefits. Table 4.4 shows the assessment of the actual effects in technical, market and collaboration dimensions by these UK companies based on their transfer experiences in China. The differences between the actual effects and complete satisfaction were regarded as risks as shown in Table 4.4.

Table 4.4 Assessment of technical, market and collaborative risks on actual transfer experiences

Supplier's consideration of risks in technology transfer	Assessment*
Technical risks	
- main technical uncertainties associated with transfer	
Quality of end-product	62%
Cost advantage for the transferred product	58%
Partner's absorptive ability of technology	37%
Market risks	
- main uncertainties affecting future market sales	
Market sales of the end-product	58%
Partner's ability to win orders	58%
Competitiveness of end-product (quality to price ratio)	53%
Customer's confidence in quality & reliability	50%
Product performance in meeting customers' needs	42%
Collaboration risks	
- main uncertainties affecting collaboration between partners	
Financial stability of foreign partner	40%
'Goodness' of collaboration	37%
Control of the technology being transferred	33%

Source: The UK machine tool survey

Note*: assessments are percentage differences between actual effects and complete satisfaction. The higher the percentage were, the higher the risks it implied.

The results shown in Table 4.4 provide a good explanation of the poor results of the actual achievement of transfer benefits exhibited in Table 4.3. The quality of end product, as the result of transferred technology, was identified to be most problematic. It in turn caused low levels of product performance and customers' confidence. The poor result in cost effectiveness led to a low product competitiveness reflected by the quality to price ratio. High technical risks resulted in high market risks. These, taken together, reduced the degree of success in market sales and transfer operations. As a result, in general less than 50% of transfer benefits that these UK companies expected were thought to have been realised in their actual experiences in China, as shown in Table 4.3.

Although the overall result seemed unsatisfactory, each individual company may have a varying degree of satisfaction. Table 4.5 demonstrates an example of these companies' assessment on the quality of end product (machines) that their partners made and there was a contrasting result between two companies' assessments (MACHCO and GILLCO).

Table 4.5 Actual results of quality of technology transfer based product made by acquirers compared with suppliers' expectation

Features of product	Average satisfaction by all UK suppliers	Assessment of satisfaction by MACHCO	Assessment of satisfaction by GILLCO
Functionality	3.0	5	1
Reliability	2.3	5	1
Accuracy	3.0	5	1
Ease of use and maintenance	3.0	5	1
Consistency	2.7	5	1
Appearance	2.3	5	1
Processing productivity	2.7	5	1
Performance price ratio	2.3	5	1

Source: The UK machine tool survey

Table 4.5 shows that the average degree of satisfaction with the quality of end product was all between *fairly satisfied* (score of 3) and *not very satisfied* (score of 2) which implies a high technical risk in general for transferring sophisticated technology. However, it is not always true in a specific case. Company MACHCO's partner produced a very satisfactory quality of machines which fundamentally paved the way to its future market success. By contrast, company GILLCO's partner was unable to provide a good quality of product to customers so the collaboration ended with market failure (for details see cases E and D in Chapter 7). It indicates that in a given market, risks were not equally shared between companies. Risks need to be specified in connection with a particular case, which further implies that in technology valuation of any transfer transaction risks, must be considered and specifically assessed.

The concern of risks in general affects the owner's value in two opposite directions. If the perceived risks are high, suppliers may doubt that their targeted future return can be achieved. In such a case the emphasis would be placed on the immediate benefits by the suppliers. The owner's value will then be determined at a higher level so that the majority of the benefits can be ensured. On the other hand, if the future market situation and the prospects of the collaborative venture are perceived to be promising so that suppliers feel confident and are more willing to seek long term benefits, the owner's value can be reflected at a lower level, particularly if a high price (acquisition cost to acquirers) could become a handicap in preventing them from achieving future gains. In the situation of either risk being perceived very high or very low, the effect of risk factor on the value of technology can be significant (see examples in case studies in Chapter 7).

4.5 Transfer Strategy: Balancing Potential Benefits and Risks

Closely linked to the perceptions of risks, foreign companies may adopt different strategies to guide their transfer activities. The case studies showed there was an impact of transfer strategies on the determination of the owner's value of technology. Given that over 90% of UK machine tool companies interviewed and/or surveyed considered *gaining the entry to market or increasing sales* and *strengthening their position in local market* as their most important transfer objectives in China, a variety of strategies, ranging from one-off transactions to equity joint ventures, were adopted by those companies. This consequently led to an effect on the owner's value. To demonstrate the impact, transfer strategies can be categorised into three groups:

a) *A no/low-commitment approach* which sought immediate benefits and was based on a one-off transfer of technology. Six companies chose this approach but claimed this was the strategy at the current stage.
b) *A limited-commitment approach* which was intended to achieve medium-term benefits and was preferred to contractual on-going collaborations. Four companies have used this approach so far. These companies perceived the market potential and believed that the

medium-term benefits would be greater than immediate benefits. However, they preferred to start with a collaboration with limited commitment and further strategy will depend on the results of previous phases.

c) *A high-commitment approach* which aimed at long-term strategic development and enhancement of local market position, was used to establish a more solid technology collaboration to be established. One company has established a JV and another one, who adopted the limited commitment approach in a previous transfer, is in the process of setting up a JV with the same Chinese partner. Another company is looking for the JV partner at present.

These strategies and their associated different levels of commitment would alter the extent to which suppliers share benefits and risks with acquirers. It further implies that a balance between transfer gains and associated transfer risks would affect the value of technology. Given the large market potential for transferring technology in China, companies who adopted the no/low-commitment approach may, at that stage, have assessed the transfer risks to outweigh the future benefits thus only the immediate return was targeted. With such an approach, the owner's value must reflect all the benefits expected from the transfer by the supplier.

For the companies who adopted the limited-commitment approach, the result of their assessments of the future benefits and risks led to a balance, in that, part (with varying degrees) of their expected transfer benefits had to be initially ensured hence would be reflected in the owner's value, while some future benefits were also targeted from the sharing of transfer value (see cases B, D and E Chapter 7).

Companies who adopted the high-commitment approach justified their higher confidence by achieving greater future benefits with less concern of transfer risks. It often implies a more solid form of partnership within which a long term benefit is targeted. As such, the owner's value is much less significant as an assurance of all transfer gains. In these cases suppliers offered their technologies as part of the investment and the value of technology was expected to increase and realise in the future (see cases C, and E at present stage in Chapter 7).

In some cases, technology was even offered free of charge in which case the owner's value appeared as 'zero'. In the case studies, it occurred when a nil or low initial value of technology was considered to be helpful to gain a good access to market (see the above case HMFGW) and to satisfy the specific arrangements of collaboration (see case F in Chapter 7).

The overall assessment above suggests that the value of technology needs to take full account of the different factors. This can mean that suppliers or acquirers may offer or accept lower or higher prices than at first seems logical. The suppliers' perception on balancing future benefit and risk has a substantial influence on the deviation between the prices they may offer and the owner's value.

4.6 A summary of The Owner's Value

The owner's value in conceptual terms should reflect the current worth of technology at the point of the value chain where the transfer transaction takes place and cover all the costs incurred upstream plus notional profits expected by the owner. However, technology not only means a product (considering embodied know-how) but also, and more important, it stands for knowledge and capability to respond to market competition (Buckley and Carter, 1996) and strategic resource (Barney, 1986), possessed by the owner. When technology is transferred it means to the owner that its advantage will be shared by the acquirer and the objective of doing so is to achieve a greater value. If the greater value can be more effectively gained through sharing the future benefits then the owner's value may not be the only means to reflect all its expected returns. Instead, the substantial parts of future gains may be often achieved through the owner's share of transfer value generated downstream.

Therefore, although, the word *value* has a close relation with *price* and *cost*, and value in general means *worth* and in many occasions it can be regarded as price and is thereby based on cost, a cost calculation is not sufficient in determining the value of technology and hence it is by no means true that valuing technology is equivalent to pricing technology. This is because, according the assessment of the factors affecting the owner's value, technology is a special product to which value can be added in its use while price can only reflect the existing value but does not take account of the future value. As shown in the HMFGW case, the future value of technology was evidently given much more consideration by suppliers when it is perceived to have greater potential. In addition, future value does not only mean financial yields but also includes benefits from long term market development (in the HMFGW case study, the long term benefits that AMO sought was the development of the local market), which however cannot be evaluated in the form of price.

It can be seen that, for an owner of technology, valuing technology is not simply a matter of determining its cost and adding a margin to earn an adequate return. The implications for the transfer, including the importance of technology to the owner itself, benefits and loss from sharing of strength, and comparing future returns with current worth, all need to be considered. The determination of the owner's value reflects the technology suppliers' perceptions of the above factors and the result of the overall assessment would be based on a balance between the potential gains and risks. As a consequence, in many cases the actual technology transfer process is not a straightforward market transaction but involves an arrangement for sharing the gains, costs and risks associated with the transfer.

In summary, the influences that suppliers perceive in the owner's value are:

i) The distinctive features of the technology being considered.
ii) The costs of development, production, distribution and those associated with transfer.
iii) The future return and potential implications from transfer.
iv) The risks and possible loss.
v) Sharing arrangements of benefits, costs and risks.

Having recognised that the determination of the owner's value is not a matter of judging its worth in the market and the owner's transfer return can also be achieved from the sharing of the transfer value generated downstream, the next chapter will discuss transfer value from the acquirers' perspective.

CHAPTER FIVE
FACTORS AFFECTING TRANSFER VALUE

5.1 Introduction

Among the value components, 'transfer value' is of greatest importance to both suppliers and acquirers. It is, on the one hand, the potential worth of the technology taking into account the share of added value generated further down the value chain which could be captured by the acquirer, and on the other hand it yields future benefits through a return to the supplier when technology is transferred through a form of on-going technology collaboration.

To technology suppliers, 'transfer value' is one of the value components to look at and their most important consideration of it is how much future returns can be shared. On the other hand, acquirers only pay attention to transfer value, as generating and capturing future value is their fundamental motivation for acquisition of technology. Since acquirers play a major role in the process of generating transfer value after technology has been transferred, this chapter focuses on assessing transfer value from the acquirers' point of view. The key questions for acquirers are related to the identification of the factors which affect transfer value and their relative influence on transfer value. The research investigation shows that, for potential acquirers, the important considerations in determining transfer value are the benefits to be derived from the acquisition of technology, the acquisition costs and its own capacity to absorb and use the technology (i.e. transfer risks). However, there are different categories of benefits, costs and risks of which some may not be fully recognised by acquirers. Discrepancy in evaluating know-how and skills between suppliers and acquirers may also exist. These factors are assessed and their implications for the transfer value are discussed in this chapter.

5.2 Transfer Benefit Assessments

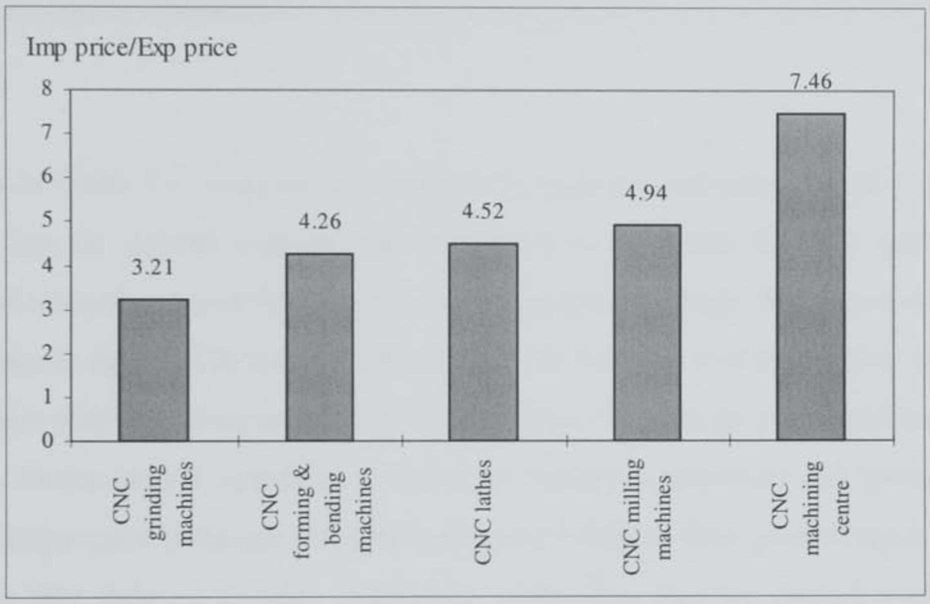
5.2.1 Identification of immediate benefits

It was identified from the surveys and case studies that for almost all the Chinese machine tool manufacturers the most obvious purpose for importing foreign technology is to increase their product sale in the domestic market. The increase of their sales revenue can be gained either by price premium or sales quantity.

5.2.1.1 Price premium and product feature performance

Compared with Chinese machines, foreign machines have an obvious advantage in price premium. According to categorised prices of China's import and export machines based on the CMTBA's source, Figure 5.1 provide an example showing that there is a large price difference between equivalent CNC machine tools of foreign and Chinese origin.

Figure 5.1 Price ratio of CNC machine tools: imports/exports to/from China (1996)



Source: Calculation based on CMTBA's statistics.

It should be noted, however, that while the categories in Figure 5.1 classify the machines according to their functions, imported and exported machines are not strictly comparable in specifications and technological levels. Nevertheless, the above evidence seems to support the questionnaire survey findings that machine tool manufacturers and users expect the prices of Chinese CNC machines to be around half for the general purpose type and less than half for the special purpose type compared to those of foreign machines (see Table 5.1).

Table 5.1 Expected price differences between equivalent CNC machine tools

	Price difference compared with equivalent Chinese machine tools expected by:		
	UK machine tool companies	Chinese machine tool companies	Chinese users
General purpose CNC machines:			
Chinese machines / foreign technology	27% higher	34% higher	33 % higher
Imported foreign machines	82% higher	84% higher	87 % higher
Special purpose CNC machines:			
Chinese machines / foreign technology	79% higher	57% higher	46 % higher
Imported foreign machines	334% higher	130% higher	112 % higher

Source: Calculation based on the UK and Chinese machine tool companies and Chinese users surveys.

As shown in Table 5.1, it appears all suppliers, acquirers and users shared a similar view on the price gap for general purpose machines between imported, Chinese made with foreign transferred technology, and Chinese made with local technology. The views are divergent for special purpose machine between suppliers (the UK machine tool companies) and acquirers as well as users (Chinese companies) with the former giving a larger price premium for imported machines. However, the significance is that all suppliers, acquirers and users perceived that there is a larger price premium for special purpose machines than general types. It also reflects their view that there is a larger perceptive technology gap for special machines between Chinese and foreign machine tool companies, and this situation was shown in cases B and D in Chapter 7.

The actual domestic market sale has further proved that the price premium of imported machines is well accepted. Despite their much higher price levels, foreign machines have been increasingly sold in China and have taken overwhelming market shares. As Figure 1.4 showed, the domestic market share for Chinese machines has declined from 70% to 35% since 1990.

These data demonstrate that customers appreciate the value of imported machine tools (product technology) and therefore are willing to pay a higher price. The reason for their preference is because of the better product quality and greater performance of foreign made machines. Table 5.2 summarises the assessments of Chinese machine tool manufacturers and users concerning the differences in major machine tool features of foreign and Chinese machines.

Table 5.2 Product feature performance: comparison between different origins of machine tools

Product features	Imported machines	Domestically made with foreign technology	Chinese machines
Ease of use and maintenance	8.19	7.72	6.87
Functionality	8.83	7.62	6.37
Reliability	8.76	6.69	5.28
Accuracy	9.04	7.75	6.44
Consistency	8.93	7.31	5.88
Processing productivity	8.43	7.51	6.07
Appearance	9.11	7.34	5.30

Source: The Chinese machine tool companies and users surveys.
Note: Scores refer to users' satisfaction on performance. 10 = complete satisfaction and 1 = no satisfaction at all.

It can be seen from Table 5.2 that foreign machines provide greater satisfaction in meeting customers' requirements in all quality elements. The only element which has a small difference is *ease of use and maintenance.* This is due to the local shortage of expertise as well as the supply of spare parts for foreign machines. Otherwise the large differences result from the gap between foreign and Chinese machine tool manufacturing technology. Table 5.3 shows further statistical analysis according to Tables 5.1 and 5.2, which indicate that superior product performance has a positive correlation with price premium.

Table 5.3 The relationship between superior product performance and price premium of foreign machines (over Chinese machine with local technology) based on Chinese machine tool companies' assessments

Foreign machines over Chinese machines	General purpose	Special purpose
Weighted average superior performance of all features	2.72	> 2.72*
Expected average price premium	84% higher	130% higher
Correlation coefficient	0.38	0.32
Significant level (F test)	0.01	0.01

Note*: The Chinese machine tool companies questionnaire survey does not provide the result of performance gap of special purpose machines but it is assessed larger than that of general purpose machines based on Chinese machine tool companies' perceptions from case studies.

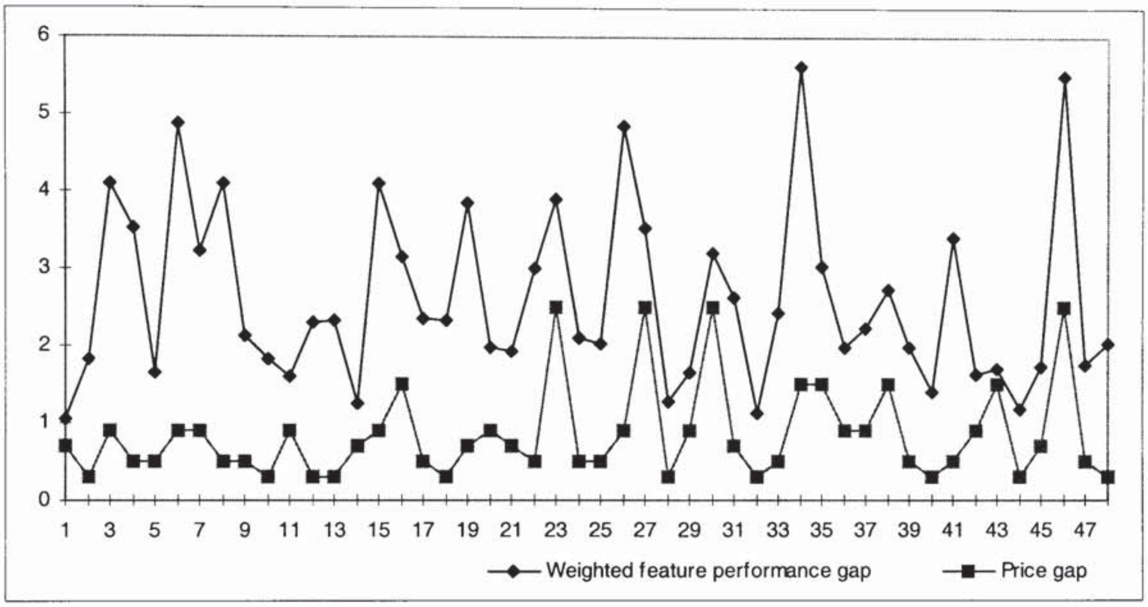
The correlation coefficients between superior product performance and price premium of foreign general type machines over Chinese ones is 0.38 by calculation. In data distribution there were some extreme values that, although they have much less frequency, reduced the degree of correlation coefficient. To obtain more accurate correlation these extreme values and least frequency were removed and the correlation was strengthened as a result (example see Pilcher, 1990). Table 5.4 shows data distribution and comparison of the results pre-and-post adjustment.

Table 5.4 Price premium index of foreign general purpose machines over Chinese machines

Price premium index = price gap ÷ performance gap	Original frequency	% of original frequency	Removal of least frequency & extreme value	% of frequency after removal
< 0.1	4	7.3%	4	8.3%
0.1-0.2	13	23.7%	13	27.1%
0.2-0.3	16	29.1%	16	33.3%
0.3-0.4	3	5.5%	3	6.3
0.4-0.5	7	12.8%	7	14.5%
0.5-0.6	5	9.1%	5	10.4%
0.6-0.7	2	3.6%	-	-
0.7-0.8	2	3.6%	-	-
0.8-0.9	1	1.8%	-	-
0.9-1	0	0%	-	-
>1	2	3.6%	-	-
Total	55	100%	48	100%
Index of central tendency: mean = 0.353			mean = 0.272	
median = 0.255			median = 0.236	
mode = 0.25			mode = 0.25	
Expected price premium = weighted average superior performance of all features x price premium index = 2.72 (see Table 5.3) x 0.353 (e.g. mean) = 96%			Expected price premium = 2.72 x 0.272 =74%	
Correlation coefficient = 0.38 (see Table 5.3)			Correlation coefficient = 0.52	
F = 8.86, significance level at 0.01 (F test)			F =16.67, significance level < 0.01 (F test)	

In Table 5.4, *price premium index* indicates the percentage of variation of price that is accounted for the performance gap. It shows that the values of indices of central tendency become closer after removal of the extreme values, therefore improved the correlation relationship between superior performance and price premium (from 0.38 to 0.52). The result of calculation on the expected price premium (74% higher) also appears to be closer to the average (see Table 5.1) from survey findings as well as opinions from case studies. More significantly, the above analysis demonstrates that the price premium of foreign machines results substantially from their superior performance. Figure 5.2 provides an illustration of this close correlation.

Figure 5.2 The correlation between performance gap and price gap compared with foreign and Chinese machines from 48 actual experiences (excluding 7 experiences with least frequent or extreme values)



Source: The Chinese machine tool survey

5.2.1.2 Product performance and its attractions to the customer

Financial return can also be increased by sales volume. The key to increasing a sales volume is basically to raise the product's attractiveness to customers, which can be measured as the degree of satisfaction that customers' requirements are met. In terms of valuing technology, the product's (technology) attractiveness to the customers can be regarded as the product's contribution to the customers' achievement of objective, i.e. the extent to which customers' objectives for purchasing product are realised. Some statistically significant results shown in Table 5.5 demonstrate the important contributions that superior product performance made to a greater achievement of the objective for purchasing machines (objective details see Table 5.6) from Chinese machine tool users' experiences.

Table 5.5 Relationship between superior performance and greater objective achievement compared with using machines from different origins

Indices	Weighted superior performance index	Weighted greater objective achievement index	Correlation between performance gap and achievement difference	Significance test (F test)
(1) Improvement index from using imported machines over TT based machines	0.772283	1.604971	$r = 0.662$ $r^2 = 0.44$	$F = 17.16$ sig. = 0.01
(2) Improvement index from using imported machines over Chinese machines	2.680994	3.204197	$r = 0.866$ $r^2 = 0.74$	$F = 65.69$ sig. = 0.001
(3) Improvement index from using TT based machines over Chinese machines	0.382424	0.777604	$r = 0.886$ $r^2 = 0.76$	$F = 78.49$ sig. = 0.001

Source: Calculation based on Chinese machine tool user survey results

A high positive relationship between superior product performance and greater objective achievement is revealed from *correlation coefficient* (r = 0.662, 0.866, 0.886). The *coefficient of determination* (r^2) shows that high percentage of change in objective achievement was tied up with the change in performance (44% of corresponding variation between imported and TT based machines; 74% between imported and Chinese made machines; and 76% between TT based and Chinese made machines). It also appears that superior performance index leads to greater objective achievement index in double magnitude between imported and TT based machines [0.77 vs 1.6, see index (1)] and between TT based and Chinese machines [0.38 vs 0.78, see index (3)]. The ratio of superior performance to greater achievement between imported and Chinese machines [2.68 vs 3.2, see index (2)] is however less than the other two categories. According to Chinese machine tool users' experiences it is because the contributions from imported machines to reducing users' production cost was assessed lower than Chinese machines (see Table 5.6).

Table 5.6 Contributions to realising objectives by using machines from different origins

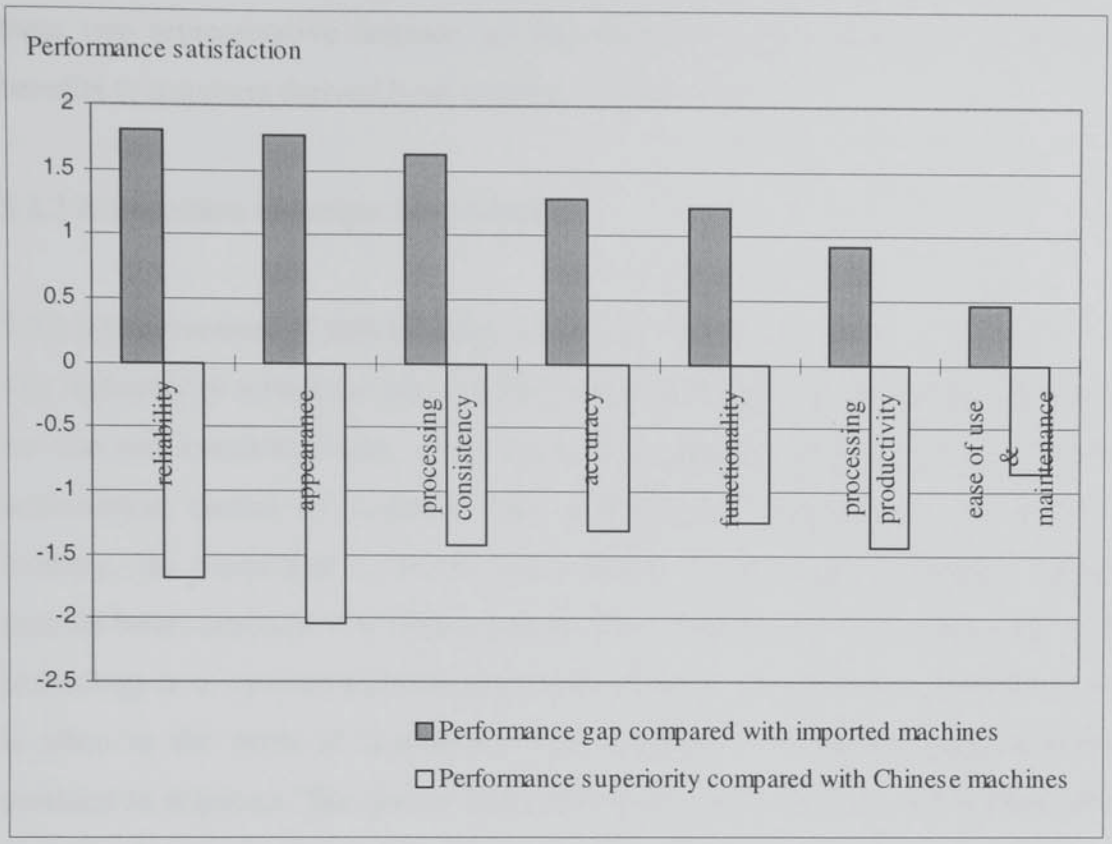
Objectives of purchasing machines	Contribution from imported machines	Contribution from TT based machines	Contribution from Chinese machines
To improve quality consistency	8.88	7.34	5.85
To produce higher quality products	9.08	7.45	5.76
To reduce processing time	7.88	6.61	5.35
To increase production capacity	7.68	6.84	5.75
To produce new products	8.37	7.18	5.55
To meet customers' specific requirements	7.00	6.12	4.63
To reduce manufacturing cost	4.90	5.39	5.50

Source: The Chinese machine tool user survey

With increasingly more severe competition from imported foreign machines, as well as a continuous increase in requirements for higher quality standard machine tools by major users, using imported technology is almost essential for Chinese firms to sell their machines to joint ventures, for example, in the automotive sector. Some specific machines were therefore in an even worse situation compared with the shrinkage of market shares for all domestically made machines as shown in Figure 1.4. Taking CNC machining centres as an example, the market share for Chinese machines was only 12% and 17% in 1996 and 1997 respectively (CMTBA, 1998).

It raises a critical issue that without a guarantee of certain degree of performance satisfaction (e.g. reliability, functionality and accuracy etc.) Chinese machines are difficult to sell in the local market despite the low price being offered. Given the situation that Chinese made machines with local technology are unable to provide good enough quality to meet customers' ever increasing requirements, such as reliability in general and special functionality in particular, it has been recognised that it is essential to improve product quality and performance by using transferred foreign technology. Figure 5.3 explicitly shows the extent of the performance improvement that acquirers have actually obtained in terms of major features of their machines with foreign technology.

Figure 5.3 Position of performance satisfaction of the technology transfer based Chinese machines: compared with imported machines and Chinese machines with local technology



Source: Calculation based on the Chinese machine tool companies and users survey

Notes: Score of 'zero' refers to the position in term of performance satisfaction for technology transfer based machines. Score above zero refers to the gap compared with imported machines. Score below zero stands for the gap between the Chinese machines with local technology and the ones with foreign technology which reflects the performance superiority of those technology transfer based machines compared with locally made machines.

Although there is still a gap in performance compared with foreign made machines, it can be seen that a greater degree of satisfaction was given in every feature to Chinese made machines with transferred foreign technology than the machines with local technology. The particular significance is *reliability*, which was regarded as the largest disadvantage for Chinese made machines, has been improved in the second greatest extent. The *appearance*, which appeared to be the largest gap as shown in Table 5.2, is improved to the largest extent. Although it was discovered that the importance of *appearance* has not been fully considered by Chinese machine tool manufacturers when they assess the technical benefits from transfers, it was claimed by the users that appearance is specifically important for the product's attractiveness to the customers in local market. From customers' point of view, the judgement for most features of machine tools can only be made through real operations after purchase.

Appearance is the only feature that customers can judge for certain before purchase therefore it is considered as the first indicator of quality for machine tools. Hence, the improvement of these two representative features, as the examples, demonstrates the immediate technical benefits to acquirers derived from transfer of technology.

5.2.2 Recognition of longer term benefits

5.2.2.1 Improvement of technological capability

The difficulty of selling the domestically made machines reveals that the fundamental reason for the non-competitiveness of products is technological disadvantage. Hence, financial achievement cannot be isolated from technological improvement. In the machine tool industry, the immediate technical improvement from acquiring foreign technology is to provide better products with higher performance. This is because machine tool manufacturing technology is of product technology in most of cases. The process of transferring technology is often in the form of introducing new products or technologically upgrading existing products to acquirers. The quality and performance of the end product manufactured by using transferred technology would be improved and, as a result, enhance the product's competitiveness.

However, from the acquirers' point of view, the ideal technology transfer should result in the ability to effectively use the technology without continuous aid and to further develop it (Aharoni, 1991). It has been found, from the previous survey, that almost 60 per cent of Chinese firms wished to acquire foreign technology to improve their technological capability (Bennett *et al*, 1996). The research questionnaire survey also shows that the capability improvement is the most significant benefit for Chinese companies to narrow the technology gap between themselves and their competitors. With such a high expectation for the technological capability development, acquirers may often, to certain extent, neglect or not fully realise that technology transfer (to the receiver) is a learning process (Aharoni, 1991) so their technological strength requires incremental improvement. The Chinese technology acquirers' experiences did show that some of the longer-term technological competitive factors were improved with less satisfaction compared with their expectations (see Table 5.7).

Table 5.7 Actual results of longer term technological competitiveness improvement

Components of competitiveness	Assessment of satisfaction
Improving production management	3.43
Reducing manufacturing time	3.16
Reducing production costs	2.91

Source: The Chinese machine tool survey

Cost reduction was assessed between *not very satisfied* and *fairly satisfied* by acquirers based on their transfer experiences. Consequently although the feature performance has been improved for Chinese made machines with foreign technology (as shown in Figure 5.3), their performance to price ratio did not turn out with higher satisfaction, 62% out of 100% (100% means fully satisfaction. Refer to Table 5.15). This price incompetitiveness has been recognised as one of the main reasons for unsatisfied sales in the local market. Then the important question is whether or not that acquirers are able to reduce their production cost to a significant level soon after they imported foreign advanced technologies. The acquirers' recognition of it would consequently affect their assessments of the transfer benefits and hence the value of technology.

For the technology transfer based machines, cost reduction may require a longer process than acquirers expected. One of the major reasons was that the supply of many key components rely heavily on imports which led to a higher level of production cost. According to CMTBA's statistics, the annual total value for Chinese made CNC machines is about US$400 million, of which half of the total value relates to imported parts. Table 5.8 gives an example that an average of 40 percent of the key parts for manufacturing CNC machines are imported (apart from spindles of which 6% are imported). This cost disadvantage led to the only around 20% of market share for these Chinese CNC machines in China (CMTBA, 1998).

Table 5.8 Average percentage of imported key parts for Chinese made CNC machines

Source of supply	Slideways	Ballscrews	CNC systems	Drives	Hydraulic parts
Imported	27%	18%	59%	62%	36%
Total average			40%		

Source: The Chinese machine tool survey

Obviously it requires a phased process to increase the local manufacturing of these key parts. To produce good quality components, whether by the Chinese machine tool companies themselves or by specialised local subcontractors, the improvement of capability will no doubt benefit from acquisition of foreign advanced technology in a long term.

5.2.2.2 Strategic development

Acquirers would also have a strategic consideration when evaluating technology's contributions (Sun, 1998). Table 5.9 provides an example of the major attributes contributing to increase of export of Chinese machine tool companies which can be derived from technology transfer.

Table 5.9 The importance of major attributes for increasing exports assessed by Chinese machine tool companies

Attributes for increasing exports	Importance
• Product quality standard	4.98
• Competitive price	4.83
• Supplier's reputation in the world	4.63
• Use of supplier's distribution channel	4.47
• Joint brand name	3.84

Source: The Chinese machine tool survey

Considering the gap between the current level of Chinese machine tool technology and the world standard, an increase in the export of CNC machines cannot be achieved immediately. The CMTBA's statistics show that Chinese CNC machine exports only accounted for 9% of the total Chinese machine tool export value in 1997. However technological collaborations with foreign companies seems effective to promote the export of conventional machines as well as parts and carcasses supply to the world market (e.g. see case F in Chapter 7). This is because foreign partners could benefit from those low cost parts or carcasses to which they will add key components and CNC control to increase the value and then sell these machines in the world market. In such a way, the foreign partners' worldwide reputation and distribution channels can be used. The raised quality standard and enhancement of their technological competitiveness are also perceived benefits that can be captured by the acquirers through technology collaborations. Although such transfer benefits may not occur immediately but through a phased incremental improvement, those perceived transfer gains are important elements of transfer value and need to be reflected in the assessment of the transfer value.

5.2.2.3 Competence in meeting customers' requirements

The assessment of transfer benefits by acquirers should also take customers' expectation into account. Customers may have specific requirements in terms of special features of machines, technical support and delivery time etc. Capability competence to meet such customers' requirements is essential to win orders in a competitive market. Table 5.10 shows Chinese machine tool users' concern with factors affecting their decision in selecting suppliers. It demonstrates their expectations for suppliers' overall capability of providing customer services.

Table 5.10 Importance of factors in influencing selection of suppliers assessed by Chinese machine tool users from their experiences

Factors	Importance in influencing selection of suppliers
Advanced technological know-how	5.11
Product warranty features	5.09
Inclusion of technical support	4.82
Inclusion of training	4.61
Quality registration	4.54
Reputation in the user's your industry	4.41
Ability to customise machines	3.81
Quick delivery	3.75
Ability to provide turnkey projects	3.35

Source: The Chinese machine tool user survey

Compared with the assessment shown in Table 5.10, Table 5.11 provides an example of the capability competence improvement of Chinese machine tool companies derived from technology transfer. Regarding the factors shown in Table 5.11, companies who use acquired foreign technology to build machines were given higher scores than those who use local technology in term of supplier's capability competence by users. However, such benefit cannot be directly reflected from the value of technology hence may often be neglected when acquirers judge the future transfer value.

Table 5.11 Satisfaction of some suppliers' factors based on Chinese machine tool user's experiences of using machines from different origins

Factors	Foreign machine supplier	TT based machine supplier	Chinese machines supplier
Advanced technological know how	8.91	7.62	6.17
Ability to customise machines	6.53	5.77	5.28
Quality registration	7.50	5.79	5.11
Reputation among your industry	7.68	7.58	6.78
Ability to provide turnkey projects	6.26	5.43	4.89

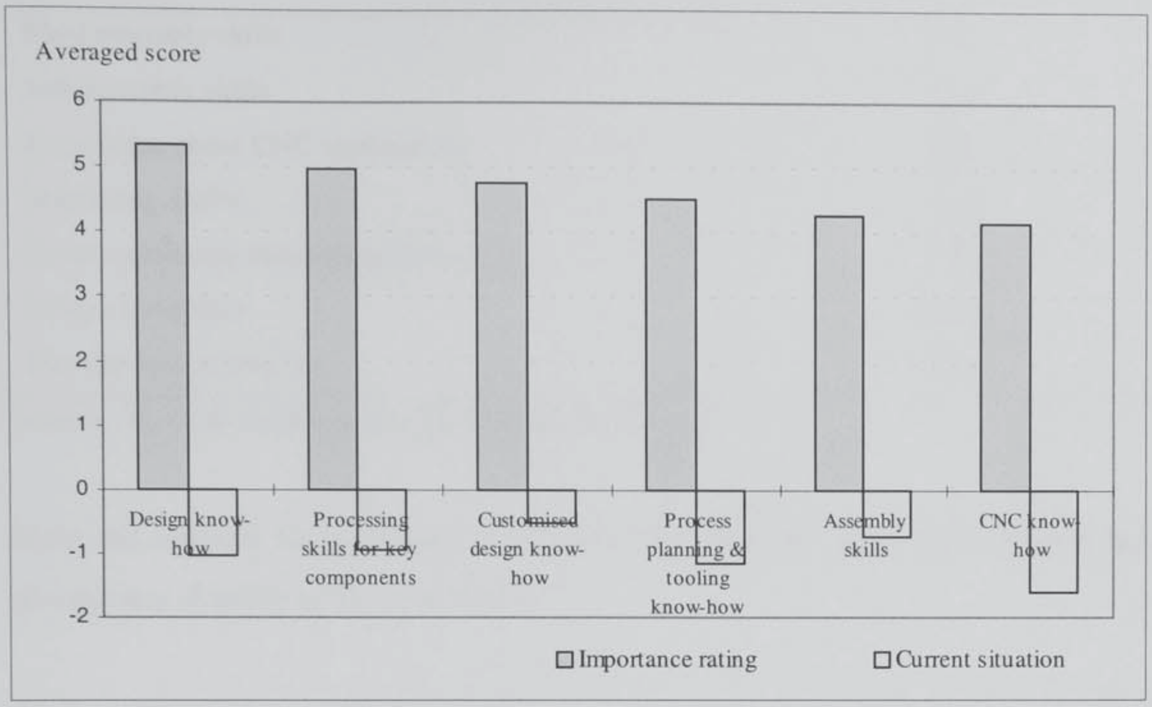
Source: The Chinese machine tool user survey

5.2.3 Know-how/skills evaluation

Machine tool manufacturing technology is a comprehensive term which includes product design and development know-how, processing know-how and skills, subassembly and final assembly skills etc. The discrepancy in evaluating know-how and skills between suppliers and acquirers also causes different perceptions of the transferred technology.

Figure 5.4 shows the comparison between the assessment of importance and the current situation regarding the know-how and skills of Chinese machine tool companies. This figure demonstrates that design know-how is most important, but this was the third worst category for Chinese machine tool companies. There is greater disparity between foreign and Chinese machine tool companies in process planning and tooling know-how and knowledge of CNC applications. As the higher degree of importance of know-how and skills implies a greater contribution to improving product quality, these "know-how" factors would therefore be given more value than others by acquirers.

Figure 5.4 Assessment on the importance of know-how and skills and the current situation of Chinese machine tool companies compared with foreign companies.



Note: Score of zero refers to *equivalent situation*. Score of -1 refers to *slight disadvantage*. Score of -2 refers to *fairly large disadvantage*.

It is interesting to note that from the Chinese companies' point of view, assembly skills were relatively unimportant compared with others, whereas assembly skills were assessed as the most important by the UK companies (see Table 5.12). As transfer of machine tool manufacturing technology normally starts with assembly skills this has been identified as one of the main areas where the gaps in evaluating whether *key know-how being transferred* or *at which stage key know-how being transferred* often exist between suppliers and acquirers. It in turn leads to the different assessment of the value of technology to be transferred. Acquirers may assess the technology to be over-valued if they think key know-how is not acquired. On the other hand, suppliers believe key know-how is transferred so would claim that technology is appropriately valued.

Table 5.12 Assessment of the strategic importance of the know-how and skills to suppliers

Know-how and skills	Importance
Final assembly skills	5.00
Sub-assembly skills	4.54
Knowledge about CNC application	4.36
Machining skills	4.36
Process planning and tooling know-how	4.27
Design know-how	4.18
Development know-how	3.63

Source: The UK machine tool questionnaire survey

From the research investigation, it revealed that there are three main reasons behind this discrepancy in defining key know-how:

(i) For technically sophisticated products such as machine tools the assembly skill, final assembly skills in particular, plays an imperative role in ensuring its quality. As most machine tools are built with bought-out and standard parts, the distinction in terms of quality, reliability and performance of machines made in different companies, to certain extent, mainly results from the assembly process. However, the standardisation of parts and components production for making machines is still at a low level in China. Quality problems in manufacturing parts and components consequently over-shadow the importance of assembly skills.

(ii) From the UK machine tool company case studies, it appeared that in developed subcontract manufacturing systems, bought-out parts account for an average of 60% of the value of a machine. Foreign machine tool companies' major activities are design and assembly, which contribute the assembly know-how and skills to the relatively more importance compared with the assessment by the Chinese companies. On the other hand, the rate of in-house production in Chinese companies is around 90%, therefore the assembly skills account for a much lower percentage in the whole expertise required for them to build a machine than for foreign companies. Because of the differences, the processing planning and tooling know-how and skills included in a transfer package may not be as sufficient as acquirers expected. As a result, acquirers may consider that the key know-how that they required was not, or not entirely, being transferred. This opinion is even more reinforced if acquirers regard processing know-how as more important than the assembly skills due to their high rate of in-house production.

(iii) A new concept of module design has been increasingly adopted by foreign machine tool manufacturers and this would lead to a higher level of standardisation in parts and components production. The specific features, such as functionality and processing productivity etc., of machine tools will rely much more on designed optional applications while maintaining a high level of using standard parts. The advantage of module design is to ensure meeting customers' requirements and meanwhile reduce production cost, thus economies of scale can be achieved. This trend would in turn, on the one hand, simplify the assembly process to certain extent, on the other hand however, further raise the importance of assembly techniques as these techniques will contain more comprehensive know-how for optional applications and skills to meet specific sophistication and accuracy requirements. Acquirers therefore need to fully realise the importance of assembly techniques and modify their evaluation standard. Although there seemed a gap between the transfer package provided by suppliers and the acquirers' requirements for entire key know-how, the extent to which transferred knowledge can improve acquirers' technological capability and, more importantly, help them move towards the new trend of machine tool production needs to be recognised and taken into account when they value transferred technology.

5.3 Acquisition Cost Assessments

For the potential acquirer the important considerations in determining transfer value, apart from the transfer benefits, are the acquisition costs for the technology (Glinow, Schnepp and Bhambri, 1991). Transfer cost, consequential and transaction cost, and intangible cost have been identified, from the case studies, as three main parts in the overall acquisition costs for machine tool manufacturing technology.

5.3.1 Transfer cost

Transfer cost to the acquirer refers to the transfer contract price that the supplier offers, which comprises a substantial part of the total acquisition cost. In the 79 transfer cases detailed in the

Chinese machine tool manufacturers' survey responses it accounted for an average of 77% of the total acquisition cost. Its breakdown included purchase of sample machines, design and drawings, CKD kits, key components, CNC controls, training, royalties and other forms of payments. The cost of each element varied substantially depending on the transfer arrangement in each case.

Because transfer cost is the most substantial cost to an acquirer and is also likely to be the supplier's most important financial reward from the transfer, it is an important factor in determining the value of the technology being transferred. Another important influence relating to transfer cost is the timing when it occurs to the acquirer (Root, 1988a), which would significantly affect the acquirers' acceptance of it. If all the transfer cost needs to be paid up front it is often not accepted by acquirers, whereas it may be accepted if some payments for it are allowed to be made on the returns from future sales. In short, because it stands for major parts of total acquisition cost so that not only its amount but also the timing of the payment would give substantial impacts on the transfer value.

5.3.2 Consequential and Transaction Costs

Consequential and transaction costs are unavoidable in most transfer processes (Geistauts and Eschenbach 1998). This is because an acquirer is often required to incur additional costs in order to more effectively absorb and make best use of transferred technology. In the 79 transfer experiences these costs accounted for the remaining 23% of total costs. These costs are mainly associated with the purchase of other relevant equipment or spare parts and fittings, marketing cost for the new product based on the transferred technology and additional staff training. Some collaborations may also involve costs for organisational changes such as establishing a joint venture with the foreign supplier or restructuring workshops within the acquirer (company) itself. The extent of each consequential and transaction cost is again different depending on the strategic and technical requirement for a specific transaction. Some transfer projects may require more such costs whereas some others may involve much less. Its influence on the value of technology is subject to the importance of these additional costs to the acquirer. The major parts of the overall acquisition cost are demonstrated in Table 5.13.

Table 5.13 Structure of the overall acquisition costs

Cost components		Percentage in total
Contract items	(77%)	
• cost of purchasing equipment		24%
• cost of purchasing technology		23%
• cost of purchasing parts & components		24%
• cost of training		6%
Additional items	(23%)	
• cost of purchasing fitting equipment		9%
• cost of purchasing spare parts & components		4%
• extra cost of training		1%
• marketing cost		3%
• cost of organisational changes		6%
Total		100%

Source: The Chinese machine tool survey

5.3.3 Intangible costs

Apart from the contract price and additional costs demonstrated above, there are also intangible costs associated with technology transfer. These intangible costs cannot be neglected despite the problems of measurement. The opportunity cost in the form of management, workforces and other resources tied up in the transfer may be significant but typically go unrecorded. Some of the major intangible costs for transferring technology are time-related. This is because that, due to the sophistication of machine tool manufacturing technology and the relatively longer production cycle to build a machine tool, the time taken for a transfer is longer than that of many other products.

One approximate indicator of such costs is the time needed before the acquirer realises the transfer benefit in the market. The survey shows that it took on average around 6 years from the time of starting negotiations until fully recovering the investment. The estimated average time for which the technology retains its advantage in the Chinese market is 8 to 9 years (see Table 5.14). However, if the technology is not successfully transferred, an acquirer may actually incur a larger loss than had been thought owing to the longer period of return.

Acquirers may therefore 'count time rather than monetary cost as their most precious asset' (Carothers and Adams, 1991). This again would have an influence on the value of technology from the acquirer's point of view.

Table 5.14 Time taken in the Chinese machine tool companies' technology transfer experiences

Activities	Average time taken (year)
Time taken to conduct negotiations	1.02
Time taken to transfer within agreement	1.02
Tine taken to realise technology in market place	1.81
Time taken to recover investment cost	3.78
Time of technology retaining its advantage in local market	8.80

Source: The Chinese machine tool survey

The acquisition cost has been found as a major factor in influencing the acquirers' decision of importing technology and perception of the value in many cases. The acquirers' concern of cost is often reflected in their preference for sharing cost with the suppliers, and this is further analysed in the discussion of terms of payment in next chapter.

5.4 Acquisition Risk Assessments

There are a number of reasons why the acquirer's perception of owner's value could be lower than that of the owners themselves. In some cases, acquirers may not be certain that they are able to absorb advanced technology and that the quality of end-product can meet the design specifications. In some other cases, acquirers may, on the one hand, not appreciate that the knowledge required to use the technology successfully cannot be gained simply from design drawings, on the other hand however, not be certain whether foreign technology could produce expected commercial yields even if it is successfully transferred. Problems may arise because just having foreign supplied parts does not guarantee the quality of whole machines being assembled locally, obtaining a new product based on transferred technology does not necessarily lead to increased sales, gaining technological advantage from transferred technology does not always improve acquirers' competitiveness in local markets and partner's performance does not consistently comply with the collaboration agreement.

The above problems clearly indicate that there are risks associated with technology transfer. The perceived benefits derived from technology transfer may not be certainly generated and captured, transfer value may not be fully realised and well-intentioned collaborations may fail. These risks would inevitably concern acquirers when they assess the transfer value. The acquisition risks which are mostly considered by acquirers are the following three types.

5.4.1 Technical risk

Technical risk in connection with technology transfer is one of the acquirer's major concerns. It has been argued that the acquirer's first concern would be whether the technology to be transferred is the latest or is well established (Stewart, 1991). It may be true in general, however, for Chinese machine tool companies this has not appeared to be the case. The reason for that, on the one hand, is that the major competitors, faced with dominant competition from directly imported machines in the Chinese market, are among foreign machine tool companies rather than local makers. Foreign technology suppliers are therefore forced to transfer their advanced technology in order to compete with other foreign companies. On the other hand, because of the rapid development of machine tool manufacturing technology, suppliers appear not to fear the possible creation of potential competitors by transferring advanced technology to their partners. Rather, they adopt the strategy of establishing a strategic alliance for gaining access to local markets as well as strengthening their joint competitiveness (Bailetti and Callahan, 1993).

As a result, the major concern with regard to technical risk for an acquirer in the machine tool sector is whether it is able to effectively absorb and best use the advanced technology it has imported. Two technical reasons have been identified from the case studies which imply high technical risks in the transfer process. One is that tacit know-how cannot be transferred in the form of drawings, nor routine instructions, but through an experience-based learning process. Another reason is that different types of technology have, by nature, different requirements in the transfer process. Specifically for machine tool manufacturing technology, it requires more systematic know-how and skills to ensure the accuracy and reliability of the whole machine. Beyond that, the 'goodness of fit' between manufacturing performance and effective use of technology requires a certain period of time to evolve. All those uncertainties would lead to the value of technology not being fully appreciated by acquirers until they actually absorb the technology and thus are able to take complete advantage of its use. Table 5.15 shows the main technical uncertainties which emerged from the 79 transfer cases reported by the survey respondents.

Table 5.15 Assessment of technical, market and collaborative risks in actual transfer experiences

Acquirers' consideration of risks in technology transfer	Assessment*
Technical risks	
- main technical uncertainties associated with transfer	
Solution to technical problems	36%
Effective use of technology	29%
Quality of end-product	29%
Absorption of technology	28%
Market risks	
- main uncertainties affecting future market sales	
Competitiveness of end-product (quality to price ratio)	38%
Product performance in meeting customers' needs	33%
Customer's confidence in quality & reliability of domestically made machines (even based on foreign technology)	30%
Collaboration risks	
- main uncertainties affecting collaboration between partners	
'Goodness' of collaboration	41%
Supply of key components	39%
Understanding and trust between partners	38%
financial stability of foreign partner	35%

Source: Chinese machine tool survey

Note*: Assessments are percentage differences between actual experience and complete satisfaction

5.4.2 Market risk

Market risk is of greatest concern to acquirers. They cannot be certain that the imported technology will bring in sufficient gain until it is realised through the sale of end-products in the market. There are many reasons that cause uncertainty about future market sales. Table 5.15 shows the most important of these. The *competitiveness of end-products* is seen to be a major concern that mainly derived from the quality (or performance) to price ratio. Foreign technology based but Chinese made machines do not seem to have much of an advantage in this respect. Their higher selling price, which is due to the high costs of imported key components, offsets some of their advantages in terms of functionality and quality. As the owner's value comprises a major part of the acquirer's costs, the consequent high price and risks concerning market sales would be taken into account by acquirers in valuing technology. Due to the large time gap between acquirers investing to import technology and realising their transfer benefits in the market, in many cases there is an unwillingness to pay for the technology 'up-front' by acquirers, instead, they often wish to share their risks with suppliers in return for longer term benefits.

5.4.3 Collaborative risk

The majority of technology transfers are undertaken through on-going collaboration arrangements. During the course of a collaboration there are considerable risks associated with the working relationship with the partners (Beamish, 1985; Killing, 1982; Osland and Cavusgil, 1996; Spekman *et al.*, 1996). Table 5.15 shows the main uncertainties about collaboration between partners that have emerged from the actual transfer cases. The risk of having a poor working relationship appeared higher because acquirers are uncertain about whether suppliers would conform exactly to the agreement. For example, the survey respondents assessed this as 39% below complete satisfaction for *supply of components*. Quite often a delay in delivery or shortage of components occurred which may consequently lead to not meeting customers' requirements or missing market opportunities.

Acquirers are also very cautious about foreign partners' financial stability because if they become bankrupt during the transfer process the acquirer could suffer considerable losses (there are several such examples in case companies' experiences). The amount of the losses depends on the transfer arrangement and terms of payment but will be at least the initial payment for the technology, the time and effort already expended and some consequential costs. Concerns about all these possible losses, either as capital investment or a missed opportunity to realise transfer benefits may cause acquirers to be uncertain about the transfer value.

Understanding and trust is important to both partners. However, in actual collaboration cases this issue did not appear to be *distrust*, rather it is often reflected as *inflexibility* in modifying some terms of arrangement when market situation changed. In order to promote market sales, acquirers may wish to have more than one range of product technology to be transferred at a time. This requirement is particularly vital when sales go through bidding for a whole production line where a number of machines with a variety of ranges are required. Under such circumstances acquirers would propose some alternative ranges of product technology to be supplied which may imply certain flexibility in carrying out the arrangement. Without good understanding and trust this flexibility cannot be approved by the partners, and it may result in a failure to capture the market opportunity as a consequence (see case E in Chapter 7). In some other cases there was even 'conflict' actually encountered with regard to the relationship between the foreign suppliers' head office, their sales office in China, suppliers themselves and their Chinese partners. The major problem in this matter was how to clarify each party's responsibility about information delivery on customers' requirements, ranges of product for sale purpose, differences in targeting markets and bid for projects (see case C in Chapter 7). Evidence has been found that those collaborative problems caused damage to partnerships as well as losses of opportunity to realise transfer benefits. The unsatisfactory return from the collaboration would result in the value of technology being misjudged.

5.5 Acquirers' Appraisal of The Transfer Value

Among the three categories of factors affecting transfer value, benefits from technology import are firstly considered by acquirers. From the above assessments, benefits can be reflected in financial gains, technical improvement and strategic development. The amount of benefits obtained depends on the acquirers' ability to provide such strength that can substantially contribute to the benefit generation and realisation. The value of technology would be consequently based on how much importance that capability is assigned by the acquirer and how much the technology can contribute to enhancing such a capability.

The contribution of technology to improving acquirers' capability provides the criteria with which to 'weigh' the value of technology. However the capability enhancement by itself does not provide sufficient information to determine the transfer value. Acquisition of technology not only provides benefits but is also associated with costs. The costs vary substantially depending on the sophistication of the technology, additional requirement for technology applications, and different forms of transaction.

In addition, the benefits generated through the use of technology depends on how effectively technology is being used which acquirers cannot be certain. The future situation of the market where technology benefits are realised is also uncertain to acquirers when technology is being transferred.

The consideration and assessment of costs and risks implies technology valuation is more complicated than for many other products. This feature fundamentally results from the nature of technology *per se*, the capability to generate benefits but not benefit itself. It is inevitable to incur costs and bear risks in the process of generating future benefits by using technology. If the costs and risks are so high that they outweigh the benefits, then acquirers may doubt the *worth* of acquiring the technology or may be uncertain about capturing the benefits from the transfer. In these cases acquirers may not agree the value, considering that the technology meant little or nothing to them if the "value" is beyond their reach.

In summary, in terms of factors affecting transfer value, cost is actual investment for acquisition of such capability, risk is uncertainty associated with using the capability and benefit is the future return of acquirers' investment. From the acquirer's point of view the transfer value can only be judged by comparing its benefits that can be generated with the associated costs and risks.

Generating and sharing of transfer value are undertaken in transfer processes in connection with forms of collaboration. The arrangement for sharing benefits, costs and risks will be specified between different forms and their influences on transfer value will be discussed in the next chapter.

CHAPTER SIX
FORMS OF TECHNOLOGY COLLABORATION AND THEIR IMPACTS ON TECHNOLOGY VALUATION

6.1 Introduction

As indicated in chapters 4 and 5, technology suppliers and acquirers not only consider the benefits derived from technology but also compare the benefits with the costs and risks associated with the transfer transaction. The value of technology would then be determined based on the balance between these factors. In a specific transfer transaction, high benefits with low costs and risks on one side means high value to one party, whereas it may give a relatively lower value to the other. In such a case, the value of technology may not be established on the basis of mutual acceptance and the good-intentioned transaction may not lead to a success as a consequence. This raises the question of how the benefits, costs and risks should be shared between the two parties within the forms of technology collaboration. Furthermore, not only would a specific form of collaboration allow different means of sharing benefits, costs and risks but would also influence the generation and realisation of future returns. Hence technology valuation and the forms of collaboration are closely related and interacted. The value of technology therefore cannot be meaningfully judged if it is isolated from a specific transfer arrangement (Bennett *et al*, 1997d).

Forms of technology collaboration refers to the technology transfer arrangements signed in a contract which directs the transfer processes and confines the transfer operations. There are many specific factors which could substantially influence the value of technology in a collaborative transfer process. Terms of transfer payment and transfer arrangements are the two major broad aspects to be considered within the context of technology collaboration. Further, transfer features associated with different transfer arrangements and their implications for the value of technology also need to be taken into account.

6.2 Terms of Transfer Payment

6.2.1 Types of terms of transfer payment

Terms of transfer payment refer to the agreed conditions on which technology suppliers' financial returns are realised, or equally, acquirers' payments for the technology are made. There are different ways through which the payment for technology can be achieved. Full payment can be made "up-front", or in parts at the commencement of each stage of the transfer processes or as a return from future sales, or they can be a combination (Bassolino and Tse, 1999). The terms of payment which are normally accepted in technology transfer between the UK and Chinese machine tool companies are mainly as follows:

(i) One-off payment: a total payment for technology acquisition is made up-front of the transfer process.

(ii) Initial payment plus royalties: a normally substantial part of the payment for technology acquisition is made at the commencement of the transfer process and the rest is made through a fixed rate of return on future sales. The rate is negotiated but normally adopts the international rate which is calculated on the basis of net sale of the product manufactured from the technology.

(iii) Instalment: a total payment for technology acquisition is divided into several parts and made at each phase of the transfer processes or over an agreed period of time.

(iv) Payment for purchase of key components: there is no direct charge for technology acquisition and acquirers only pay for their purchase of key components (based on the agreed terms and conditions) supplied by the technology suppliers.

(v) Share of returns from future sales: there is no direct charge for technology acquisition. Suppliers achieve their financial benefits through sharing of the returns from future sales.

6.2.2 Terms of transfer payment and sharing arrangements

From the UK and Chinese machine tool companies' technology transfer experiences it is shown that, to both suppliers and acquirers, different types of payment implied different means of sharing benefits, costs and risks:

(i) No sharing of benefits, costs and risks (i.e. one-off payment);
(ii) Part sharing of benefits, costs and risks (e.g. initial payment plus royalties or instalment at each phase); and
(iii) Greater sharing of benefits, costs and risks (e.g. payment for purchase of key components or share of returns from future sales).

Under a *no sharing* arrangement an acquirer gains all the future benefits but also bears all the costs and risks. Since costs and risks are normally high it effectively leads to a devaluation of the technology from the acquirer's side. In the machine tool industry, unless acquirers are confident of their own capability as well as the market situation they are usually unwilling to support the idea of one-off payments (Ostroff, 1995). On the other hand, suppliers can immediately realise all their financial return from transferring technology without bearing any costs and risks. However, they have also no any access to the benefits generated in the future and have almost no control of the use and development of the transferred technology either.

Under a *part sharing* arrangement suppliers bear some of the costs and risks and in turn it allows suppliers to share some of the future benefits. By the same token, but to a different extent, acquirers share the rest of benefits, costs and risks. In case studies this has been found to be a popular type of payment in many of the transfer transactions. This is because it is easier to be accepted by both parties (Stewart, 1988).

The *greater sharing* arrangement allows more sharing of benefits, costs and risks between two parties which implies a closer partnership for technology collaboration. Because it helps to reduce acquirers' uncertainty and especially allows acquirers not to pay for the technology until the benefits are actually realised, it often promotes a strong willingness to accept the value offered by suppliers or, in other words, leads to a higher value as judged by acquirers due to the reduction of costs and risks that otherwise they would bear.

6.2.3 Preferences of terms of transfer payment and sharing arrangements

More specifically, *one-off payment* (no-sharing) and *initial payment plus royalty* (part-sharing) are the terms under which acquirers are required to pay the entire or a substantial part of technology acquisition charges up-front. Acquirers therefore prefer not to accept these two terms when the contract value (price) is high (see Table 6.1).

Table 6.1 Assessment of the suitability of terms of payment compared with different level of transfer contract value (price) based on the acquirers' actual experiences

Contract value (price)	One-off payment	Initial payment plus royalty	Instalment at each phase	Payment for supply of key components	Share of return from future sale
<US$ 5 million	3.47	2.35	3.44	3.50	4.28
>US$ 5 million	1.94	2.22	3.57	3.69	4.72

Source: The Chinese machine tool survey

Table 6.1 shows that one-off payment and initial payment plus royalty were assessed as *not very suitable* when the contract value is higher (for example) than US$ five million, as acquirers would bear a relatively higher level of financial risks under such circumstances. Terms of payment such as instalments or payment for supply of key components appeared to be acceptable regardless of contract value. However, acquirers mostly prefer the term that the payment would be made through a share of the returns from the future sales as their costs and risks can be shared to a greater extent with the suppliers (Tasng, 1994).

Table 6.2 shows the terms of payment actually being used in the technology transfer experiences by the surveyed Chinese machine tool companies while Table 6.3 provides an example of preference in general for different terms of payment between suppliers and acquirers.

Table 6.2 Terms of payment being used in Chinese machine tool companies' technology transfer experiences

Terms of transfer payment	Number of times being used	Percentage in total transactions
One-off payment	17	25%
Instalment	22	32%
Initial payment plus royalty	5	7%
Payment for key components	12	17%
Share of return from sales	13	19%
Total transactions	69	100%

Source: Chinese machine tool survey

Table 6.3 Priority given to different terms of payment by UK technology suppliers and Chinese acquirers

Terms of payment and types of sharing arrangements	Assessments of suitability by suppliers	Assessments of suitability by acquirers
One-off payment	3.5	2.41
Average in no sharing	***3.5***	***2.41***
Initial payment plus royalty	4.4	2.82
Instalment	4.25	3.76
Average in part sharing	***4.33***	***3.29***
Payment for key components	4.4	3.48
Share of return from sales	2.75	4.37
Average in greater sharing	***3.57***	***3.92***

Source: The UK and Chinese machine tool surveys

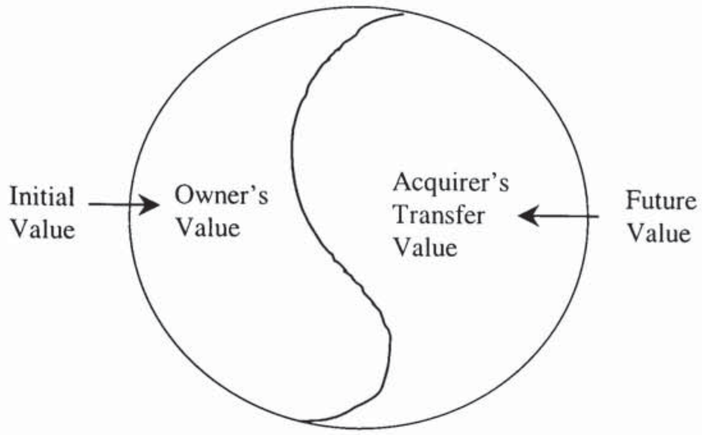
Table 6.3 demonstrates the difference in the preference of the sharing arrangement between suppliers and acquirers: suppliers are more in favour of *part sharing* while acquirers prefer to *greater sharing*. These preferences are understandable as the transfer value of technology is often not known when the agreement is made. Considering the large time gap between the commencement of investment in technology transfers and realisation of transfer benefits in the market, both sides are cautious of the transfer costs and risks. To suppliers, the choice or willingness between greater sharing of future benefits, costs and risks and capturing immediate benefits with less bearing costs and risks depends on their perceptions of local market potential, partner's capabilities, importance of the technology to be transferred and their transfer strategies (Bassolino and Tse, 1999). When suppliers were uncertain about future returns and market situation or when they simply sought short term benefits, they assessed *no sharing* as a suitable arrangement.

6.2.4 The impacts of sharing arrangements on value - initial value and future value

Based on the above assessment it is seen that the terms of payment does not change the total value of technology. Rather, its impact on value is through arranging the share of value between suppliers and acquirers. If the part of value being realised by the acquirers' up-front payment is defined as *initial value* and the remaining part to be achieved by the future payment is defined as *future value,* technology valuation can be, as far as the impact of terms of payment is concerned, regarded as a matter of how to divide the value into initial and future parts and how to decide the shares between two parties.

The initial value refers to the current gains which technology suppliers intend to capture through the transfer of technology to acquirers. As mentioned earlier, in the case of one-off transactions, suppliers have no access to the future value (generated by using technology downstream), while acquirers, on the other hand, would incur an immediate cost for the technology acquisition (and may also need consequent investment) as well as bear all the risks, and as a result, gain all the future benefits yielded by using the technology. In such a case, the owner's value is equivalent to the initial value while transfer value equals all the future value taken by acquirers. Since there is no sharing of future value in one-off transfer, the value that suppliers realised is confined to financial terms which makes it easier to value technology than in on-going transfer transactions (see Figure 6.1).

Figure 6.1 Technology valuation in one-off transactions - no sharing of future value between suppliers and acquirers

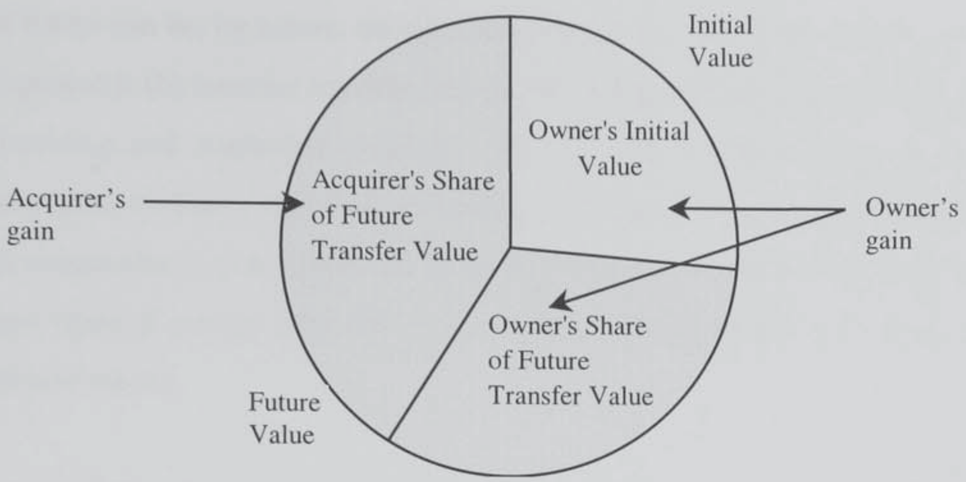


Value of Technology

Valuing technology is much more complicated in the case of on-going collaborations. In such a case the value of technology will be further added and needs to be shared between suppliers and acquirers. The transfer value which refers to the further generated value would no longer be only gained by acquirers as it was in the one-off transfer. Suppliers will share the future returns as they also bear costs and risks in the process of collaboration. The extent to which suppliers and acquirers share the transfer value would vary depending on the arrangement for sharing costs and risks.

As the future value will be shared between partners, it often in turn leads to a significant change in the initial value. The initial value has no longer necessarily to reflect all the current worth of technology as suppliers can realise part of the value in the future. As the HMFGW case (in Chapter 4) showed, the initial value may be well below the owner's value, or in some cases there is even no initial charge if suppliers seek to share more of the future value. To the supplier, the total return is therefore the sum of the owner's initial value and a share of future transfer value, while the remaining part of the transfer value forms the return to the acquirer in an on-going collaboration (see Figure 6.2).

Figure 6.2 Technology valuation in on-going collaboration - sharing of future value between suppler and acquirer



Value of Technology

As sharing arrangements actually determine how much of the value is to be captured by each side within the available, jointly generated, total value, both suppliers and acquirers need to be fully aware of their impacts on technology valuation.

6.3 Technology Transfer Arrangements

6.3.1 Types of transfer arrangements

There are many types of transfer arrangements for transferring technology. In a study in 1987, the United Nations Centre on Transnational Corporations distinguished two types of technology transfer, commercial and non-commercial. The forms of commercial technology transfer include (Meryer-Stamere 1990):

- foreign direct investment enterprise (wholly-owned subsidiary)
- joint venture
- licensing
- franchising
- marketing contracts
- technical service contracts

- turn-key contracts
- international subcontracting

The forms can be, by nature, mainly classified as: (a) one-off transfer (e.g. direct sale, turn-key project); (b) contract transfer (e.g. licensing agreement, subcontracting, co-production, franchising and marketing contract); and (c) joint ventures (including contractual and equity joint venture). As far as technology transfer between Chinese and foreign machine tool companies is concerned the following forms are identified as the currently accepted major types of arrangement. Within each specific arrangement technology is transferred by different means:

a) One-off purchase of technology hardware: technology is acquired through purchase of machinery equipment with embodied technology, training for machine tool operations and drawings included.

b) One-off purchase of technology software: technology is acquired through purchase of drawings with training for machine tool manufacturing included.

c) Licensing agreement: technology is acquired through purchase of the right for the use of technology, sample machines and key components with drawings, specifications and training being provided.

d) Subcontracting: technology is acquired through subcontract manufacturing parts, assemblies or machines with drawings, bill of materials, build specifications, key components, training and technical supervision being provided.

e) Co-production: technology is acquired through a contract based purchase of sample machines and key components, and machines being jointly built with drawings, bill of materials, build specifications, intensive training and technical supervision being provided.

f) Equity joint venture: technology is acquired through joint capital, technology and other resources investment so that technology is accessed in all necessary forms with continuous training and technical support.

Table 6.4 shows the forms of collaboration actually being used in the technology transfer experiences of the surveyed Chinese machine tool companies.

Table 6.4 Forms of technology transfer used in Chinese companies' actual experiences

Forms of transfer	Number of times being used	% in total transactions
One-off purchase of machine with drawings	13	17%
One-off purchase of drawings with training	6	7%
Licensing agreement	18	23%
Co-production	14	18%
Subcontracting	14	18%
Joint venture	13	17%
Total transactions	78	100%

Source: The Chinese machine tool survey

6.3.2 The link between terms of payment and technology transfer arrangements

In a technology transfer arrangement, for commercial reasons suppliers will, at least, expect the costs of the technology to be covered by a monetary return. By the same token, acquirers will wish to ensure the future returns can cover their payments for the technology. On this basis, both sides also expect to gain more financial benefits. Terms of transfer payment are the means to satisfy these financial needs in a transfer arrangement. As assessed above, an initial payment and/or a future payment (or payments) would reflect the value of technology to be achieved through an initial value and/or future value, which further implies an arrangement of sharing commercial benefits, costs and risks between the two parties. This sharing arrangement however depends on the types of transfer arrangements in terms of the level of commitment.

Figure 6.3 shows that the looser the transfer arrangements which are adopted, the less sharing of benefits, costs and risks between suppliers and acquirers is required. On the other hand, the higher the commitment in a collaboration is established and the further stages the payments are required, the greater sharing is achieved. The distribution of costs, risks and benefits varies substantially between types of transfer arrangements in connection with the level of commitment.

Figure 6.3 Sharing of benefits, costs and risks in different transfer arrangements

Acquirer takes all future benefits, costs and risks

Decrease in acquirer's share →

Decrease in acquirer's share ↓

	One-off payment	Initial payment plus future royalties	Phased instalments	Payment for supply of key components or price discount on buyback	Share of returns from sales
One-off transfer	*				
Licensing		*			
Subcontracting				*	
Co-production		*	*	*	*
Joint venture		**			*

Increase in supplier's share ↓

Increase in supplier's share →

Supplier and acquirer share benefits, costs and risks

Notes: The "star" stands for actual cases where such a sharing arrangement was established from the research case studies. The 'star*' refers to an exceptional case (shown in case C in chapter 7) as normally there is no royalty payment in a JV arrangement.

The terms of payment only reflect how financial benefits are shared between suppliers and acquirers. Technology transfer however not only generates financial benefits but also involves technical and strategic aspects. Given terms and conditions that the supplier and acquirer will share the benefits in financial terms, there are two further questions that require consideration by both parties: a) how to transfer the technology effectively so as to technically ensure the targeted and future-shared benefits to be generated? b) what would be the strategic benefits which may be derived from a transfer arrangement? These two questions are directly connected to the types of transfer arrangements, which should be established as a means to generate and realise the expected value of technology.

6.3.3 Technical requirements in technology transfer arrangements

Technological knowledge is not simple information that can be bought or sold, rather, it is rooted in the on-going organised activities of design and production (Zysman, 1992). Hence, technology transfer is not simply a matter of change of ownership, nor is it just selling rights of use but a process of delivering systematic new knowledge and utilisation of the know-how in production (Cusumano and Elenkov, 1994; Holt, 1988). The time required for transfer, and the effort necessary for learning and absorption, depend on the degree of sophistication, codifiability and teachableness of the technology (Kogut and Zander, 1993) and the technological gaps, including the quality and capacity of equipment and the stages of knowledge, between suppliers and acquirers (Bohn, 1994). As mentioned earlier, to build a machine tool it requires more systematic know-how and skills, whereas the transferability of machine tool manufacturing know-how is relatively lower due to its lower degree of standardisation, high complexity and simultaneous information processing. Many transfer experiences, whether successful or not, have shown that to ensure the quality and good performance of a machine, know-how and skills must be absorbed systematically and used appropriately. Taking special machines, such as transfer lines, as an example, not only technology of how to build the machine needs to be transferred, but know-how of accurately and efficiently processing components and sequencing operations is also required (see Case D in Chapter 7). Given the complexity of the technology transfer process, to the acquirer, it needs time to evolve from receiving the material and design to capability improvement (Cusumano and Elenkov, 1994).

These difficulties explained why there are technical requirements in the processes of transferring machine tool manufacturing technology. The technical requirements demonstrate that a well-planned technical training and support arrangement and an experience-based learning process for absorption and accumulation of knowledge are critically important. It would help acquirers to more effectively absorb the transferred technology and consequently to achieve the best use of the technology. In the research case studies there were several examples that showed how technical problems led to a poor financial result and eventually resulted in the end of collaboration due to the inadequate technical supports (see Case D in Chapter 7).

Therefore acquirers would normally expect the provision of some transfer features which could help to satisfy these technical requirements. Table 6.5 show the acquirers' assessment of the importance of major transfer features for transfer compared with these features being provided in their experiences.

Table 6.5 Acquirers' concern: assessment of the importance of technical requirements and the occurrence in their previous experiences

Transfer features	Importance of transfer features	Included in transfer arrangements in actual experiences (%)
Greater advanced technology provided	5.26	70%
Key know-how transferred	5.26	41%
Technology being kept updated	4.23	30%
Inclusion of training	4.16	52%
Key components supplied	3.87	48%
Extensive product range included	3.58	28%

Source: The Chinese machine tool survey

Table 6.5 shows that three main technical features, *key know-how transferred*, *technology being updated* and *training being provided*, were actually included in the transfer arrangements at a rather low percentage among all the surveyed Chinese machine tool companies' experiences. These are arguably the main reasons for poor results or technical failure in technology transfer, as training, technical support, and learning-based transfer process are vital elements of transferring the "software" of the technology (Ostroff, 1995). Another related feature is that machine tool products are continuously modified and improved. The transfer of technology for a new development cannot therefore be a one-off process. As a consequence, the required improvements in technology also tend to create their own further problems requiring modification and revision, thereby making continuous transfer inevitable (Rosenberg, 1976; and also see case F in chapter 7). If the transfer arrangement does not adequately reflect this necessary technical requirement, the technical handicap may not be overcome.

Considering the technical requirements for transfer, suppliers are also aware of the importance of the acquirers' technical capability by judging from the acquirers' technological level, quality of their current product and equipment being used (see Table 6.6).

Table 6.6 Suppliers' concern: assessment of the importance of technical factors in determining potential partner over the alternatives in their previous experiences

Technical factors for choice of partner	Importance of factors	Being considered in actual experiences (%)
Better quality of currently-made product	5.2	40%
Better quality of production equipment	4.9	20%
Higher technological level of products	4.5	40%
International product quality registration	4.4	-
Greater production capacity	4.0	-
Technical competence	*	20%

Source: The UK machine tool survey.

Note: * The UK companies specified factors, of which the rate of importance was not given.

Table 6.6 demonstrates that suppliers, in order to reduce transfer cost and rapidly realise transfer benefits in markets, apparently place more emphasis on acquirers' existing technological capability. This intention is revealed from their major technical considerations in selection of partner and from the experiences of relatively inadequate technical support they actually provided to acquirers in the transfer process as shown in Table 6.5.

The acquirers' perception of value can then be influenced by the technical transfer features themselves in the transfer arrangement. As shown in Table 6.5, there were only 41% that included key know-how transfer and 30% that obtained the provision of updated knowledge in the surveyed Chinese machine tool companies' transfer experiences. A cause of gaps between suppliers and acquirers in the value of technology is that, although suppliers provide advanced technology which was therefore highly valued, the acquirers may not be given access to the key know-how. Given that technology means capability to acquirers, if a transfer of technology does not effectively lead to an improvement of an acquirer's technical capability, the acquirer may not appreciate the value of technology as much as the supplier does. The consequent technical problems have a further impact on the value of technology, which may prevent acquirers from the seeing complete advantage from the technology, and this would lead to a judgement of low value.

6.3.4 Strategic consideration in technology transfer arrangements

Although strategic achievement is not as easily measured as financial return it has been always considered to be an important benefit derived from technology collaboration by both suppliers and acquirers. Obviously, suppliers firstly need to decide how best the technology can be exploited, either by internal activities or by external collaboration. If collaboration can add more value, it often provides a strong incentive for establishing a globalised manufacturing strategy to develop new markets and exploit local advantages. In some cases, suppliers may enter a technology transfer arrangement primarily for broad strategic reason with limited prospect of financial returns in the short term. Table 6.7 provides a result of the suppliers' assessment of the importance of their strategic objectives. Those strategic elements would be incorporated into the technology transfer arrangement in order to achieve the enhancement of the suppliers' strategic position in the local market through such a collaboration.

Table 6.7 Suppliers' assessment of the importance of achievement in relation to the enhancement of their strategic position in local market

Strategic achievements	Importance
Company's reputation	4.9
Product competitiveness in the local market	4.6
High market share in local market	4.3
High profitability	4.3
Development of local supply chain	3.7
Increase in exports to neighbouring countries	2.9

Source: The UK machine tool survey

Acquirers would also consider the potential contribution of the acquired technology for their future competitiveness. The development of their strategic strength is the essential guarantee to enable them to achieve sustainable financial gains. Improvement of their technological capability and access to the world market are in general two broad strategic targets which they expect to realise through technology collaboration (Bennett *et al*, 1997b and 1999c; Ostroff, 1995; Zhao *et al*, 1998). Table 6.8 shows acquirers' assessments of the importance of the arrangement features relating to their future strategic development.

Table 6.8 Acquirers' assessment of the importance of achievement in relation to their strategic development

Strategic achievements	Importance
Technological competitiveness in domestic market	5.25
Upgrading technological level of product	5.18
Improving technical development capability	4.96
Technological competitiveness in the world market	4.61
Developing a new domestic market niche	4.29
Improving company/product image	4.15

Source: Chinese machine tool survey

The consideration of strategic development has an important influence in collaboration arrangements hence the perceptions of the value of technology. The higher opportunity of achieving strategic benefits is perceived the more willingness that suppliers may have to share benefits, costs and risks to a greater extent with their partners. For example, they may closely commit themselves to the collaboration by offering more favourable terms of transfer payment to the acquirers. With the highlight of suppliers' consideration and judgement of the possibility of achieving strategic benefits in relation to their willingness to share, Table 6.9 indicates the impact of their strategic considerations on the value of technology through determining terms of transfer payment. As mentioned earlier, terms of payment directly reflect the sharing arrangement of financial gains, costs and risks, therefore have a critical influence on the acceptability of the value to both suppliers and acquirers.

Table 6.9 Suppliers' assessment of the importance of factors in determining the terms of transfer payment concerning types of no-sharing, part-sharing and greater-sharing

Terms of transfer payment determining factors	Importance
Company's strategies for transfer (short, medium or long term)	5.00
Knowledge and confidence about your local partners	4.78
Partner's technological capability	4.56
Local market potential where technology is transferred	4.22
Perceived potential transfer benefits in collaboration with partner	4.11
Willingness to share costs & risks with partners in developing countries	3.89
Immediate transfer benefits	3.33
Partner's local market share	3.11

Source: The UK machine tool survey

It should be noted, however, that suppliers will probably wish to retain some control over the technology so as to reduce the potential threat of competition. By the same token, acquirers need to be aware of the gaps between their strategic aspirations and their current capabilities, in order to judge the potential contribution of acquired technology to their future competitiveness and further development. These considerations emphasise that it is important for technology to be valued within the specific context of a technology collaboration, where these factors can be specified.

6.4 Transfer Features In Connection With Transfer Arrangements and Their Impacts on The Assessments of The Suitability of Transfer Arrangements

Transfer features (as shown in Table 6.5) have an influence on the actual effectiveness of technology absorption. However, different collaboration arrangements may link with different transfer features, which may be fully included in some arrangements whereas they may be provided to less extent in some others. For example, according to the experience of the Chinese machine tool companies, all the on-going collaborations included training, whereas training was only provided less than half in one-off transactions. Transfer of "key know-how" also occurred less frequently for one-off transactions (35%), while in co-production arrangements it was higher (70%). "Greater advanced technology being transferred" was assessed as around 50% in one-off transfer arrangements. In comparison over 92% of joint ventures claimed that they were provided with the latest technology.

Some features may be connected with specific transfer arrangements and excluded from others. 30% of on-going collaborations involved arrangements for technology to be updated during the process of transfer, but this was not the case for one-off purchases of technology. This is also the case regarding the feature of "buyback agreement". Apart from subcontracting in which this feature was included, there were also between 25%-30% of other on-going collaborations that included buyback agreements while this was completely excluded from one-off transfers.

Due to the important contributions derived from these transfer features and the differences of these features in different forms, the transfer results were, as a consequence, shown to vary under different transfer arrangements (see Table 6.10).

Table 6.10 Acquirers' satisfaction with the results of technology transfer under different forms of transfer arrangements

Forms of collaboration	Absorption of technology	Effective use of technology	Quality of end-product	Customer's confidence
One-off transaction	6.92	6.92	7.12	6.67
Licensing	7.25	6.67	6.47	6.67
Co-production	6.67	6.88	7.12	7.12
Subcontracting	7.82	7.18	7.43	6.92
Joint venture	7.30	7.82	7.20	7.08

Source: The Chinese machine tool survey

Note: Score of 10 stands for fully satisfaction

In general, an on-going collaboration produced better transfer results in terms of effectiveness of transferring technology than a one-off transfer. It implies that the contributions from these transfer features which were included in a closer partnership were greater towards enabling acquirers more effectively to absorb and use technology in the transfer process. It can be seen from the results of actual transfer experiences (shown in Table 6.10) that, overall, there appears to be a slight advantage from including the transfer features mentioned above. However, there is no clear indication from these survey results that they are as important for success as has been suggested by the case studies. Nevertheless, by using SUR (seemingly unrelated regression) statistical analysis, Table 6.11 does show there is an impact from specific transfer features to acquirers' assessments of the suitability of transfer arrangements with the implied relationship between some features and arrangements.

Table 6.11 The impacts of transfer features being provided in acquirers' experiences on their assessments of suitability of transfer arrangements

	One-off transfer	Licensing	Co-production	Subcontracting	EJV
(a)	0.946	0.621	2.239*	2.295*	2.427*
(b)	0.934	1.622*	0.802	1.279*	0.709
(c)	n/s	0.964	n/s	0.887	1.147
(d)	-0.659	n/s	n/s	n/s	n/s
(e)	1.712*	n/s	1.457	1.148	n/s
(f)	n/s	0.652	2.053*	2.217*	1.817*

Notes:

- The function of SUR is to estimate the impact/attribute of independent variables on/to dependent variables.
- The independent variables are the transfer features which include:
  (a) supply of greater advance technology; (b) key know-how transferred;
  (c) inclusion of training; (d) technology being updated;
  (e) lower price; and (f) access to world market
- The dependent variables are the assessments of the suitability of transfer arrangements
- The relationship between variables indicates the extent to which transfer features can influence acquirers' judgement of the suitability of transfer arrangements
- Coefficient refers to incremental degree given to the suitability
- Coefficient with * means its significance is at the 1% level. Coefficient without * means significant at above 10% level.
- n/s means the coefficients are not significant or meaningless results.

Table 6.11 implies the following results:

(i) Transfer features of *supply of greater advanced technology* and *key know how being transferred* are the most important judgmental criteria in acquirers' assessment of the suitability of forms of collaboration. The joint venture is shown to be the most suitable form to gain advanced technology.

(ii) The provision of *key know how* is in general closer to on-going arrangements.

(iii) There is closer relationship between provision (or greater extent of provision) of *training* and *access to the world market* and a more solid collaboration arrangement.

(iv) A one-off transfer is regarded as an unsuitable arrangement (a negative coefficient) when *technology being updated in the transfer process* is taken into account but seems more attractive when a lower value of technology is offered.

As a result, acquirers showed a strong preference for higher commitment arrangements (see Table 6.12) to seek more technical support from the suppliers. The Chinese machine tool survey indicates that there was no joint ventures as an engine for technology import in 1980s but JVs that were adopted to acquire foreign technology accounted for 30% of the total transactions in 1990s within these companies' experiences (for examples of JV which provides better opportunity for acquisition of technology also see studies: Cohen and Levinthal, 1990; Dutta and Merva, 1990; Newman, 1992; Young 1988). The research case studies further revealed that acquirers have different perceptions of the value of technology in different transfer arrangements. It was also identified that these differences were due to their awareness of the impacts of transfer features on actual transfer results in terms of whether technology can be entirely acquired, effectively absorbed and used.

Table 6.12 Suitability of forms of transfer arrangements assessed by the experienced companies

Transfer arrangements	Assessment by Chinese companies	Assessment by UK companies
One-off purchase of technology	3.22	3.13
Licensing agreement	3.49	4.00
Subcontracting	4.36	2.75
Co-production	4.39	3.40
Equity joint venture	4.58	3.00

Source: The UK and Chinese machine tool surveys

On the other hand, as Table 6.12 indicates, suppliers do not normally have such a strong intention as acquirers to commit themselves into a closer partnership until their previous collaborations have achieved satisfactory progress. The three noticeable approaches (mentioned in Chapter 4) that suppliers are most likely to choose regarding technology transfer strategies provided an explanation for the suppliers' assessment. These strategies apparently require different levels of commitment and will directly alter the extent to which suppliers share benefits, costs and risks with acquirers. However, suppliers need to be aware that less provision of technical support (in order to reduce their transfer costs) may imply a higher risk in terms of the transfer result. It happens particularly when this feature is vital to improve the acquirer's weakness in absorption, or to enhance the effectiveness of use, of the technology. Under such a circumstance inadequate technical support would lead to an unsatisfactory outcome. As a consequence, although a part of suppliers' return from transferring technology can be realised through the owner's initial value their targeted future return from shares of future transfer value may not be achieved (for an example see case D in Chapter 7).

Further to this strategic issue, suppliers require to decide the margin between their initially realised value and their expected future value. From the above assessments, it may lead to two opposite considerations for suppliers: (a) they should raise the initial value to an even higher level so as to further reduce shared future risks, and (b) they should reinforce their commitment and provide more technical support so as to enhance the chance of generating greater future value. There are consequently two important implications for technology valuation:

(i) The transfer arrangement influences the value of technology by affecting how the value is realised, taking into account the future value generation in all financial, technical and strategic aspects.

(ii) The transfer arrangement also influences how value is shared, but in a different way compared with the influence from the terms of transfer payment. The terms of transfer payment determine the share within the value available to share, while transfer arrangements significantly influence at which stage of value chain, either *greater future joint value* or *current worth* or in between, the value is shared.

6.5 Summary

Forms of collaboration have a substantial influence on the absorption and use of transferred technology. A judgement about the value of the technology requires consideration of how much of such capability of yielding beneficial returns can be delivered in a collaborative operation. In this respect, attributes associated with specific collaboration arrangements in contributing to effectively using capability need to be taken into account.

Benefits generated and risks associated in transfer processes are actually a reflection of the effectiveness in terms of delivery and use of the technology. Cost, on the other hand, is an indication of how much commitment and efforts are being made in the practice of delivering and exploiting the capability. An arrangement for sharing benefits, costs and risks reflects each party's activities involved and contributions made within a specific transfer arrangement. The next chapter discusses the transfer processes and results in different cases and, consequently, their impacts on the suppliers' and acquirers' perceptions on the value of technology.

CHAPTER SEVEN
CASE STUDIES

7.1 Introduction

This chapter introduces selected case examples from the research investigations. The complexity of valuing technology shown in these cases demonstrates that the commercial, technical and strategic considerations were required and the effects of their interactions on technology valuation need to be considered. The cases selected were all on-going collaborations which showed the development their collaborative operations, and allowed key factors affecting the value of technology at different stages and the impacts of performances of each party on the technology valuation to be identified. Each case also had distinct features in terms of (a) transfer strategies/approaches, (b) collaboration arrangements, and (c) phases and features of transfer process. This provided the identifications of the characteristics which were related to suppliers' and acquirers' value considerations within different collaboration arrangements. These characteristics helped to justify the impacts of both suppliers' and acquirers' objectives for technology transfer, their assessments of technology attributes and the transfer results on their perceptions concerning the value of technology. The revealed insights from the cases would help to develop the technology valuation framework.

Except for Case A, the cases were longitudinal 'pair-case' studies. By investigating both partners these cases provide exceptionally rich insights into valuing technology within the context of a technology collaboration. The majority of these cases were compiled using multiple visits over a period of two years between 1996 and 1998. Information for cases C and E were updated in 1999. The investigation of case F has been being carried out to the present. For reasons of commercial confidentiality, the names of all the companies have been changed.

Each case study started with the background context and the description of transfer arrangements. The format which was used in the analysis of each case was identical in order to make comparison. The format include: both parties' motivations for transfer, assessments of transfer results in financial, technical ands strategic aspects, and the implications for valuing technology. The chapter summarised the major issues drawn from the cases on the technology valuation, in which the features of each case were compared.

7.2 Case A. BAIHE Machine Tool Works (BAIHE)

7.2.1 The context

The firm belongs to the Ministry of the Machinery Building Industry in China[7] . It is one of the largest machine tool factories in China with 7,000 employees. Its main products are milling machines, machining centres, 'gantry' millers and tools. Annual output is 3000 machines, among which 100 are gantry millers. The average output value is around RMB 500 million in which CNC and NC machines represented 15%. Exports amount to approximately US$4-5 million which are mainly standard milling machines.

Since 1980, the Chinese government has invested RMB 300 million to assist the factory's technical development. To upgrade its production equipment, more than 40 CNC machines have been imported including a flexible manufacturing system (FMS). The factory has also obtained financial assistance from the UN since 1985.

The factory has its own R&D group and introduces 4 to 5 new products per year (some are entirely new and some are modifications to existing products). The overall variety of products comprises 300 models of machine, however, only about 30 models are built each year. Around 2/3 of production is to stock and 1/3 is to customer order, particularly for large machines.

7.2.2 Brief description of transfer arrangement: co-production agreement with MILLCO

- Year when contract signed: 1984
- Status: continuing
- Forms of collaboration: coproduction
- Foreign partner: MILLCO
- Technology type: special purpose

[7] The Ministry became the Bureau of Machinery Industry in China's further economic system reform in 1998.

- Technology product: NC gantry milling machine
- Terms of payment: share returns from future sale
- Targeted market: local market
- Transfer arrangements:

- MILLCO: supplying drawings and training, manufacturing 60% of parts (mainly electronic parts) by value, checking quality of local parts;
- BAIHE: manufacturing 40% of parts by value, conducting final assembly and selling product in Chinese market.

- Collaboration outcome by the end of 1996: 8 machines have been sold in China at an average price of RMB 0.5 million for each.
- Benefits gained:

- MILLCO gained a majority market share for this type of machine in China.
- BAIHE acquired and absorbed the technology and is in the leading position in terms of manufacturing gantry millers in China.

- Features of collaboration:

According to each customer's specific requirement BAIHE and MILLCO identify the parts that each party to produce. The price for each machine varies depending on the proportion of labour division between the partners.

- Intended further collaboration: newer models will be co-designed by the two companies. BAIHE will make the machines and the machines will be supplied to the Chinese and European markets through BAIHE's and MILLCO's distribution channels respectively.

7.2.3 Case analysis

7.2.3.1 Motivations

BAIHE perceived that there were two routes for technology development: (a) technology transfer and (b) development in-house. Without much experience and expertise of developing advanced technology by its own efforts, BAIHE preferred to transfer technology. It believed that it was an effective way to acquire advanced technology and regarded it as a crucial step for its technological development. Owing to the market demand and its own technical inadequacy BAIHE had been looking for a prospective foreign partner with a reputation for building this type of machine. Meanwhile MILLCO found it hard to sell into the Chinese market because of price incompetitiveness of its machines. A co-operation to build the machines to reduce the cost was therefore attractive to MILLCO. It aimed at accessing the Chinese market and sharing returns from sales, while BAIHE expected to benefit from the technology transfer.

7.2.3.2 Financial aspects

A gantry milling machine is a special purpose type so the product is completely made to order and specification is based on customers' requirements. The market risk is therefore lower than the machines built for stock. In addition, shipping costs for gantry machines are much higher due to their large size, which gives imported foreign machines a larger cost disadvantage. As a result the market competition for this type of machine is less severe than for many other types of machine. It helped to build a winning chance for this collaboration in terms of market sales. The dominant local market share has been acquired as a result of the collaboration. The financial value of technology was achieved with satisfaction to both sides. Given that BAIHE already had the equipment to build gantry machines there was not much additional cost for the production while in many other cases these costs were normally quite sizeable. The factory did not involve much financial investment and as a result the input to output ratio of the collaboration was regarded as high.

7.2.3.3 Technical aspects

BAIHE already had experience in building gantry milling machines and has built a good reputation in the domestic market for producing big millers. With the government financial support and assistance from the UN the factory has good R&D facilities and production equipment. All these attributes made a contribution to effective absorption of the transferred technology and to maintaining the quality of the end-products. These two factors were identified as critical issues in technology transfer and have been evident as major technical reasons for failure in unsuccessful technology collaborations in the Chinese machine tool sector. Cost-reduction practice also benefited from the above attributes as the low consequential costs contributed to the low total production cost.

7.2.3.4 Strategic aspects

Both parties were clear about their strategies and objectives as well as their consequent influence on the terms of collaboration. The importance of market share for the product and the strategic position in the Chinese market were recognised. Commitment was therefore high in terms of efforts made despite low capital investment. More importantly, each party's targeted return was related to its contribution towards the generation of the total benefit. Each partners' contribution was determined by an assessment of the respective capabilities of each to achieve the collaborative objectives and to meet customers' requirements. As a result, the collaboration actually enhanced the opportunities for both parties to generate a greater joint benefit.

7.2.4 Implications for technology valuation

For an effective collaboration, each party needs to locate its critical success factors and focus on these to gain competitive advantage (Kogut, 1991). In this case, the consequent good effect on valuing technology was that each party's targeted return was appropriately based on its capability. This was solved through the identification and highlighting of each side's complementary strength in the collaboration and a corresponding sharing arrangement of joint future benefits. Not only did it help to enhance the opportunity of generating the targeted return but it also provided guidance to establishing the value of the technology. Both parties could then clearly perceive their joint benefits from their collaboration.

To both supplier and acquirer the costs and risks associated with the collaboration were assessed lower compared with perceived future gains. Neither party was involved in much capital investment for the transfer. To the acquirer, there was also little direct consequential cost required for the transfer due to its already updated production equipment. Technical and market risks were also seen to be reduced by the acquirer's existing capability and good reputation for this specific type of machine in the local market.

The solid foundation led to an increasingly positive commitment and trust which improved collaboration efficiency. Each party achieved satisfactory results in terms of technical competitiveness and market shares. The sales revenue was shared as the financial returns to each party on the basis of the contribution that each party made to generating the joint benefits. The value of technology and the significance of their collaboration were therefore highly appreciated by both parties along with the realisation of their transfer objectives.

7.3 Case B: FANHE Metalforming Press Works and ADCO

7.3.1 The context

7.3.1.1 FANHE Metalforming Press Works (FANHE)

FANHE was established in 1957 and from 1960 it specialised in metal forming machines. Since then it subsequently developed plate bending and tube bending machines. It was the first factory in China to specialise in these types of machine.

There are 1700 employees in total, of which around 500 are engineers or management staff and 1000 are shopfloor workers directly involved in machine tool production. It is the largest factory in the world to produce plate benders in terms of volume. The total of its output of plate benders had been 7,600 sets by 1997. The firm also produces various metalforming machines such as: tube benders, section benders, press breaks and plate shears. In addition, levelling machines, tube-end forming machines and cut-to-length lines were designed and developed in the 1990s for the domestic market. It currently has 12 major product ranges including 30 series and over 200 models.

Manufacturing capacity was doubled during 1980s. The full production capacity is 600 sets/lines of machines annually. As increasingly more heavy machines, complete production lines and CNC machines have been produced, the output quantity is decreasing but types of machines and the unit-value are increasing. The average output value is RMB 100 million per annum. CNC machines reached 40% of the total annual output in 1996.

The factory had technology transfer experience before the collaboration with ADCO was established. In 1984 there was a co-operation with a Japanese company (FJ) for a three-roller plate bender. Based on FJ's technology the factory developed several types of plate bender with different adjustments.

Its export markets include nearly all countries in South-East Asia and also the USA, Japan, Africa, and some European countries. The annual export value plus the investment in foreign technology imports have reached 30% of its output value. Hence, FANHE claims that it is relatively more reliant on the world market (i.e. exports plus technology acquisition) compared with many other Chinese machine tool companies.

7.3.1.2 ADCO

ADCO was formed in 1956, one year before FANHE, but was initially only an importer. After 5 years of selling tube benders it went into production with its own-designed machine. The company now embraces design, manufacturing and selling tube bending machines and offers technical services. There are 160 employees in the company.

ADCO is one of the top 5-6 companies in terms of output value and among the top 1 or 2 in terms of technology in the field of tube bender manufacturing. Its machines can bend from 3mm dia to 275mm dia steel (the largest bending diameter in the world) with up to 16mm wall thickness. An advanced draw bending technique is used in bending process.

ADCO currently buys-in 60% of the parts to make CNC benders. It used to have a lower percentage of bought-out parts, but as benders have become more sophisticated and components such as drives have changed from manual to automatic, the value of bought-out parts has increased. However, computer control is designed and made in-house as commercial CNC machine tool controllers are not suitable for tube bending.

40% of machines are made in small batches to a market forecast and 60% are made to order. Sales have increased steadily over the last 8 years at an average annual rate of around 12%. The annual sales turnover was over £10 million in 1997. Around 85% of its machines go to the automotive industry, among which 40% are used for bending exhausts and 45% for other automotive applications. The remaining 15% is used for making tubular furniture, shipbuilding, aerospace etc.

7.3.2 Brief description of transfer arrangement: licensing agreement

- Year when contract signed: 1986
- Status: terminated by the end of 1997
- Forms of collaboration: licensing agreement
- Technology type: special purpose

- Technology product: CNC tube bender
- Terms of payment: initial fees plus royalty payments. Initial fees were £62,000 for the first four models and £15,000 per model thereafter. Royalty was 5% of invoice price less cost of equipment purchased from ADCO for first twenty machines. The subsequent machines was 4%.
- Transfer arrangement:

- ADCO: provision of drawings, training, CNC controllers and other key parts.
- FANHE: manufacturing other parts (such as hydraulic parts), performing final assembly and selling products in domestic market.

- Benefits gained:

- ADCO obtained payments for supplying technology and key parts plus royalties from sales.
- FANHE acquired parts of the technology to make CNC tube bender and shares of return from sales.

- Features of collaboration:

- Transfer process was phased in 5 years and the judgement of the result was made by the two parties at the end of each phase. Training was provided for each model and two ADCO engineers visited FANHE for four weeks to inspect and commission initial Chinese built machines.

- Results: 11 models have been transferred and 34 machines have been sold in China, including a maximum diameter (275mm) CNC tube bender.

7.3.3 Case analysis

7.3.3.1 Motivations

Since the mid-1980s, China's automotive industry has been growing at a fast pace. Attracted by the market potential there has been a large investment from many global car manufacturers into China's automotive industry. These foreign subsidiaries or joint ventures require a high quality of components with a large quantity but the Chinese made production equipment cannot meet the rising needs (e.g. all Chinese tube benders were manual machines and there were no CNC tube benders made in China).

Being aware of the fast increasing demand for tube bending machines and without such expertise, FANHE, decided that co-operation with foreign companies was the best way to develop new machines. On the other hand, ADCO also perceived the market potential and the fact that there were only a few foreign made CNC benders sold in China. There was a good opportunity of developing the Chinese market for the CNC type bending machines, where ADCO has technological advantage. With the assistance from MTTA through its link with CMTBA, a licensing agreement for making a CNC tube bender was established between FANHE and ADCO.

7.3.3.2 Financial aspects

Between 1986 and 1994 FANHE built and sold 34 machines in China from which ADCO gained £2 million as the transaction revenue. Compared with ADCO's total annual turnover the averaged annual project revenue, however, only accounted for 2.5%. On the other hand FANHE was also in a similar financial situation. Its averaged annual transaction turnover (after deducting the amount paid to ADCO in the forms of initial payment for technology, purchase of key components and royalties) accounted for 2.3% of its total annual turnover. The net profit (after deduction of its own costs) was only equal to 0.5% of its total turnover. Both parties have not achieved sufficient financial gains through their collaboration.

7.3.3.3 Technical aspects

Although FANHE has a reputation for building plate benders it had no previous experience of making CNC tube benders. The manufacturing technology for producing tube benders is far more sophisticated than that for the former and as a result the absorption of technical knowledge was more difficult. In order to produce good quality machines a good understanding of the machine is primarily required. ADCO however retained its proprietary know-how (e.g. design and manufacturing of CNC controllers, software listings and the majority of proprietary electrical equipment) without providing them to FANHE which actually led a only limited understanding of the technology by its partner. Given FANHE's technical objective of improving its capability to develop its own new product from the collaboration, the acquisition of key know-how was a major factor in judging the technical value. The technical value of the technology was hence regarded by FANHE lower than expected due to the limited acquisition.

From ADCO's point of view, owing to its technology leadership in manufacturing this special type of machines, the only technical benefit that may be derived from the collaboration with FANHE was the cost reduction. However, the poorer quality of locally supplied components was seen to have caused problems with the performance of FANHE made machines. It required ADCO to continue supplying the key components to its Chinese partner. There were over 50% of FANHE's total manufacturing costs that were spent in purchasing the key parts from ADCO. The possible added value from reducing costs was rather limited. As this situation was expected to remain for a foreseeable future ADCO recognised that it may be unlikely to gain much technical benefit in terms of reducing costs through the collaboration. On the other hand, cost advantages have not become the critical element for this special type of machines in the competition in the Chinese market because of its early stage of the product life cycle in the local market. Therefore, technical value was a less important, and nor an immediate technical benefit in this collaboration from ADCO's concern.

7.3.3.4 Strategic aspects

Along with the rapid growth of the automotive industry (ADCO's major user industry) in China, ADCO sought good access to the Chinese market to more effectively exploit the perceived market potential. It aimed at developing a prosperous market for its products. FANHE's strategic objective was to improve its competitive capability so as to develop new products and new markets by acquiring advanced technology. The strategic value was dependent on the extent to which the key know-how could be acquired to meet its strategic objectives. Both parties expected to realise their objectives through their technology collaboration with improvements in technology and market share. However, FANHE did not acquire the core technology to enable it to develop new products. Neither has ADCO achieved sufficient financial gains to maintain its enthusiasm in continuously developing its business in the Chinese market with FANHE. The strategic value from further collaboration was assessed as low by ADCO and as a result it decided not to continue the partnership.

7.3.4 Implications for valuing technology

From FANHE's point of view, there were two major considerations about the imported technology: integrity (i.e. the whole technology rather than part of it to be transferred) and compatibility (i.e. suitability for local market demand) as far as the value is concerned. The 'integrity' of technology in this collaboration was seen a major issue. Key know-how which were essentially required for the acquirer to improve capability and develop new product were not provided. The acquirers therefore cannot fully appreciate the value of the technology. In the assessment of the importance of transfer objectives in the research questionnaire survey, FANHE placed *improve the technological capability* as the first priority which accounted for 32% in importance weight. This perception placed more stress on the acquirers' dissatisfaction with the result of objective achievement as improving technological capability relies heavily on the acquisition of know-how.

FANHE also believed that the only criteria for an acquirer to value the transferred technology was transfer value, which needs to be realised and judged in the use of technology (e.g. cost reduction and quality improvement etc.) and through market sale (e.g. product competitiveness and attractions to customers etc.). Therefore acquirers prefer to prove the value of technology through the market before the payment is made. In the contract with ADCO the initial payment was required and payment of large amounts for proprietary parts was continued. When compared with limited future sales revenue and also taking into account the lack of key know-how provision, FANHE was not convinced that the value of technology was as high as it had paid for.

According to FANHE's summary, the technology from ADCO was not considered to be as appropriately valued as those in its experiences with the FJ (Japan) and HELE (German) companies. Some comparisons are shown in Table 7.1.

Table 7.1 Comparison of technologies acquired from different collaborations in FANHE's experiences

	Technology product	Technology complexity	FANHE's experience of making the product	Key know-how acquired	Terms of payment
FJ	Plate bender	Low	Yes	Yes	One-off
ADCO	Tube bender	High	No	No	Initial payment plus royalty
HELE	Large plate bender	Medium	Yes	Yes	Share return from sale

FJ's technology - for making a three-roller plate bender- was relatively simple to FANHE as it had more experience of making plate benders. FANHE acquired the whole technology and the product (technology) was appropriate to the Chinese market. Thus a one-off transaction was chosen. FANHE benefited from FJ's technology in its new product development of 3 and 4 roller plate benders.

ADCO's technology was highly complex while FANHE had no previous experience. Key know-how was not transferred hence FANHE's understanding of the machine was limited. The objective of improving capability for new product (a CNC tube bender) development therefore cannot be achieved. Also, compared with acquisition costs and risks, the rate of future financial yields was low.

HELE's technology was provided free of charge. All the payment would be against future sales of the co-made machines so there was not much financial cost and market risk for the acquirer to bear. The value of technology was to be judged through market.

In the process of production there were few technical problems and FANHE's technical capability was considered to be good enough by ADCO. The key technical problem was the poor quality of locally made components, which resulted in unsatisfactory quality of the whole bending machine. It led to the result that the benders which were branded 'FANHE-ADCO' could not reach the same quality standard as the benders made by ADCO in the UK (the quality of 'FANHE-ADCO' benders could meet users' requirements from general machinery makers but was not good enough to satisfy Sino-foreign joint ventures in the automotive industry which was ADCO's key targeted market).

Being aware that the technical problem may not be solved in a short time, ADCO considered an alternative for the collaboration that FANHE could only focus on making less sophisticated NC benders with the technical support from ADCO, while the high specification CNC type would be supplied by ADCO to the Chinese market until the existing technical problems could be solved. This intended arrangement, however, did not occur owing to continuous poor market sales in the last three years of the contract. The high selling price can be considered as one of the reasons for poor sales as the typical price of an ADCO machine is £100,000 (ranging from approximately £50,000 for a small machine to £500,000 for a large one). The selling price in China was similar because many high value key parts were supplied by ADCO so the cost level remained high. The quality to price ratio of FANHE-made ADCO's machines was even more incompetitive as far as quality problems were concerned.

Despite FANHE claiming that it made efforts to promote market sales, it has failed to take any order since 1996. ADCO recognised that the most problematic area in this collaboration was FANHE's inability to turn technology advantage into commercial benefits. Market failure was the root cause of the decision (of ADCO) not to renew the contract when it ended in 1997.

To ADCO, although it gained £2 million revenue, the financial return from this technology collaboration was lower than expected, particularly taking into account its technology advantage as well as the good market opportunities in China. There was no fixed amount of financial return that can indicate how much the financial value of the technology should be, it, however, can be argued that the technology may not have been best used in such a collaboration and a greater future value may be generated from other alternatives for which ADCO is currently looking in China.

7.4 Case C: JINSHA Machine Tool Company and LESCO UK

7.4.1 The context

7.4.1.1 JINSHA Machine Tool Company (JINSHA)

JINSHA originated from BAIHE Machine Tool Works (see case A) in 1966. There were 600 workers moved to Sichuan (inland area in China) with an initial investment of RMB 3 million to produce milling machines. The move was a part of the plan of anti-invasion (assumed from the former Soviet Union) made by the Chinese government. The firm, with a current total capital of RMB 400 million, was transformed to a shareholding company in 1988 and listed on the Shenzhen Stock Exchange in 1995. It was one of four Chinese machine tool manufacturers listed on the Chinese stock exchange.

The company has 2300 employees including 600 technicians and management staff. The annual production is about 1500 machine tools with around RMB 130 million output value. Production is planned according to market demand and production to customer order accounts for substantial rate which remained over 90% since 1993.

Machine tool products can be divided into 5 types and 45 models in which the major products are knee type milling machines, copy milling machines (both with distinctive features) and machining centres. Like many other Chinese machine works its machines include both manually operated and CNC types. Products have a nation-wide domestic market and are also exported to 38 countries or regions mainly in Asia, Africa, America, the Middle East and Australia. The export value is around US$3m which accounts for 20% of the annual output.

The company has complete production facilities which contains design and development, technical preparation, casting, forging[8], parts machining, heat treatment, assembly and after sales service etc. The fully integrated operation indicates a high rate of in-house production.

JINSHA pays special attention to technological development. Technology was developed by itself, assisted by some imports. Some high-tech products have been developed (e.g. digital machine tools). The company's technical level is advanced among Chinese machine tool manufacturers. By international standards it is equivalent to the early 1980s, however its mechanical/electrical integration is equivalent to the early 1990s standard, assessed by JINSHA itself.

The importance of quality is stressed and technological renovation plays an important part in the guarantee of its production standard. All the investment was aimed at technological improvement. Between 1991 and 1995 the company invested US$2.23 million in importing machines from Switzerland and the USA to upgrade its production equipment. Also in 1993 the factory acquired a Spanish government long-term loan of US$5 million to import 9 advanced machine tools and other equipment. As a result, the company has had the comprehensive range of equipment needed by an advanced machine tool factory to manufacture high standard products.

7.4.1.2 LESCO UK (LESCO)

LESCO is a subsidiary of LESCO US - a long established company with a worldwide reputation. The whole LESCO company's major products are milling machines and machining centres. The product range extends from manual tool room milling machines to

[8] The forging department was separated from the rest of production and incorporated into a joint venture with a local firm in 1995.

multi-axis vertical and horizontal CNC machines with high capacity tool magazines. The feature of LESCO's machines is to keep high accuracy with capacity of heavy metal cutting.

LESCO makes horizontal and vertical CNC machining centres. The company is largely autonomous in operation. Its number of employees varied in the decade between 300 and 800 depending on market situation. Currently it has less than 500 employees. Sales turnover also varied with a low level of £25 million and a high of £60m. Over 1000 machines were built annually between 1995 and 1997. Exports account for 60% of sales.

The company has sold machines to China for a number of years, primarily through a Hong Kong based agent. More than 500 machines have been sold to Southern China where the Hong Kong agent concentrated most attention. More recently LESCO has undertaken a non-exclusive agreement with a second agent, Tai Tung Industrial Corp, which has offices in Beijing, Shanghai, Guangzhou and Shenzhen and other major cities. LESCO also has its own sales office in Beijing to conduct direct sales and service activities in the Chinese market. The company's intention is to gain more widespread sales in China.

7.4.2 Brief description of transfer arrangement: contractual joint venture

- Year when contract signed: 1995
- Current status: continuing
- Forms of collaboration: contractual joint venture
- Technology type: general purpose
- Technology product: CNC vertical machining centre
- Total capital investment: US$2.4 million. LESCO invested $1.15m (48%) of which the technology contribution was US$600,000 accounting for 52%. The remaining US$1.25m (52% of the total investment) was invested by JINSHA in the forms of factory and equipment etc.
- Terms of payment: LESCO gains 48% of the profit, based on its share of the joint venture, plus 4% royalty on sales. Royalty payment was initially 5% but LESCO reduced it by 1% for re-investment instead.
- Transfer arrangement:

- LESCO: capital investment supplied in the forms of technology (drawings and training), sample machines, CKD parts and a laser alignment machine.
- JINSHA: providing capital for building factory and other equipment, recruiting employees for JV, manufacturing castings and machining parts.
- Joint venture: operation includes final assembly and selling products in the local market.

• Benefits to be gained:
- Commercial benefits are through both parties sharing return from sales. LESCO also gains royalties from transferring technology. JINSHA would acquire the technology to make the vertical CNC machining centre as its new product in the local market. Both parties seek long term benefits by developing their market and increasing shares.

• Features of collaboration:
- The operation started initially with CKD kits assembly. CKD contents would be gradually reduced along with the manufacturing operation moving forward locally. Localisation were planned to increase gradually to 90%. The first year was regarded as a training year. The product started with vertical machining centres. Twenty machines were planned in the first year of operation commencing in 1996 and thereafter production would increase according to demand. In the third year the horizontal machining centre was planned to be introduced. LESCO would be interested in buying back machines when its existing market situation improved.

• Results so far: Seven machines were sold in 1997 - the second year of the planned operation in the JV, and since then 9 machines have been sold up to the middle 1999.

7.4.3 Case analysis

7.4.3.1 Motivation

There has been increasingly fierce foreign competition in the Chinese machine tool market in the 1990s. The domestic market share of imported machines increased by almost 10% per annum since 1993. The shrinking market share for Chinese machines led to more serious competition and a challenge to the Chinese companies. The means of competition was in general through new technology/product design (substantial part of which was imported), product quality and after sales service. Faced with this situation, JINSHA fully recognised the importance of gaining a competitive advantage by means of technology collaboration. Its objectives for technology collaboration include: enhancing its capability for making high quality and good performance products; improving its capability for providing a high quality of customer service; and learning advanced management know-how and methods.

JINSHA had earlier technology transfer experiences with LESCO (US) and P&W (US) in the mid-1980s. Both of these transfers were arrangements for co-production. The products were NC milling machines of different types. As a technical benefit, JINSHA developed new products based on the transferred technologies with modifications. These machines (two types of NC miller: XK5038 and XKF718) have been sold in the Chinese market. From its experiences, JINSHA has identified different ways of co-operating with foreign companies. It, however, prefers joint ventures which were considered to be more suitable for realising its overall objectives for acquisition of technology.

Along with the fast growth of the Chinese market, in LESCO's perspective, selling machines in China was no longer just a bonus but became an important strategy. This change was reflected in its approach toward the collaboration arrangement with its Chinese partner. In the previous partnership with JINSHA, LESCO's (US) primary objective was to use cheap Chinese labour to produce low cost machines. The collaboration was only considered to provide a low cost production base from which to supply machines for their own markets. The operation was not for accessing the Chinese market and there was no solid commitment made in that arrangement. As a result, LESCO (US) was unable to benefit from the sales in China although JINSHA had sold more than 40 sets of XK5038 (the machine developed based on LESCO transferred technology) in the domestic market by 1996. LESCO recognised in its previous experience that it had lost out on benefits from the Chinese market potential.

LESCO's new strategy was to seek long term benefits. Pursuing this objective LESCO intended to establish a highly committed collaborative venture to which it would make available its latest technology and management knowledge. LESCO expected the venture to produce good quality standard machines and promote sales in the Chinese market. To meet the requirement, a JV was considered as an appropriate arrangement for the collaboration.

Following the previous partnership LESCO approached JINSHA to propose a further collaboration. Being aware of LESCO's worldwide reputation JINSHA already had a strong willingness to establish a long term partnership with it. Although River Machine Tool Works, a factory located in the same province, was an alternative partner for LESCO to consider, the provincial government gave a preferable support to JINSHA. Therefore LESCO and JINSHA signed a JV agreement in 1995. It was registered as a contractual joint venture (CJV) because the value of the technology shareholding was too large (52% of LESCO's investment) for it to be given the status of an equity joint venture (EJV) according to Chinese JVs law. However the related policies on tax concessions from the central and provincial government apply to both types of JVs.

7.4.3.2 Financial aspects

Instead of capital input, LESCO used its advanced technology as a major part of its investment to own 48% of the joint venture. Its financial gains are from a 48% share of the profit plus 4% royalties from future market sales. From JINSHA's point of view, the technology was regarded as being valued on the high side when compared with its own US$1.25m capital investment. Nevertheless, JINSHA would obtain the remaining profit (after deducting the returns to LESCO) as payoff therefore both parties expected a financially win-win collaboration. With this high expectation the initial planned output quantity was 75 machines in year 1, and 100 in year 2. Soon after the agreement signed, both parties released that the original plan was too ambitious (given the consideration of the time required for the shipment of CKD kits to the JV and the employees training etc.) so the target was adjusted, and the planned output of year 1 was reduced to 20 machines. Nevertheless, the actual production was still 50% below the modified annual plan. In year 1, only 10 machines were built and the machines were not all sold until the middle of the next year.

The originally planned schedule for the start of the operation was delayed and the process also slowed down because the JV moved to a new site in 1996. A more serious problem as a result of the delay was that the scale of economies that would derive from local manufacturing became more urgent as CKD kits (supplied from the UK) assembly appeared not to be profitable due to the high manufacturing cost in the UK. Higher transportation costs were also incurred because the JV was located in inland China where is logistically poorer for an efficient transportation. The combination of delays in localising manufacturing, increased expenses, and poor market sales produced unsatisfactory results.

Two other factors may also have contributed to the unsatisfactory financial return. One was how to effectively co-ordinate among the LESCO's distribution channels, which include the JV itself, the Chinese partner, LESCO Beijing Office and sales agents, for selling its products in local market. The level of co-ordination between all the above channels was found not sufficient to allow customers' requirements to be efficiently communicated to the JV. The second factor was that the marketing infrastructure in the JV was not fully established and this weakness may have led to missing out some potential market opportunities.

7.4.3.3 Technical aspects

The substantial part of technical benefits to both parties have yet to be realised. Instead of exploiting the cheaper labour, LESCO's objective was to make machines of European quality in China and to train the JV's employees to the necessary high standard. The JV was expected to represent LESCO's image by being able to manufacture high quality LESCO machines and supply them to nation-wide markets in China. JINSHA also hoped to acquire the latest technology through the JV operation, and focused on improving its capability to make higher quality standards machines and to upgrade the technological level of products.

The learning process however actually slowed down due to the difficulties in market sales. Know-how and skills obtained were still mainly within the scope of assembly. Product design and development know-how were thought to be most important where the gap was also the largest between the partners. The JV however has not gained much knowledge of these areas in its operations, nor have the JV's activities involved key parts processing.

With the full awareness of LESCO's worldwide reputation and advanced technology, JINSHA however satisfied with the transfer arrangement within which LESCO agreed to keep the technology updated during the course of collaboration. It believes that such a solid collaboration will generate significant technical benefit in the future, hence the perception of future technical value of the technology remains high from the Chinese partner.

7.4.3.4 Strategic aspects

LESCO had a strategic view on its business development in China. The options it considered at the early stage in 1994 included:

- setting up a sales office in China
- segmenting and targeting the Chinese market by provinces, industries etc.
- co-operating with a Chinese company via licensing, co-production or a JV
- using China to exploit the regional market in the longer term.

By examining the options and considering short, medium and long term issues, LESCO decided to seek the long term benefit. Its strategic approach towards the Chinese market is rather "positive" compared with many other UK machine tool companies. The form of technology collaboration (JV) with Chinese partner that the company has chosen demonstrates its long term commitment to the co-operation. JINSHA also showed a strong willingness to establish a strategic alliance through which to enhance its competitive position in the local market. Long term development was sought by both parties.

The highly committed joint operation has actually led the management, mutual trust and understanding issues to becoming critically important. At the early stage of this collaboration, the level of trust and quality of understanding did not appear to be compatible with their high commitment. There was confusion about the partner's knowledge of local markets, costing control and the criteria for selecting employees for the JV. Communication and feedback were sometimes not effective and efficient. As it progressed, the operation also encountered unexpected problems in management. LESCO intended to improve the efficiency of the transfer by directly participating in the operation and management but the result, to certain extent, was a failure in the management of the joint venture. It was because of the unsuitable managing skills, employee discipline and culture differences between the top management and employees. The general manager (a Singaporean) was appointed by LESCO, partly because of his previous experience of working with LESCO Singapore and partly because he could speak both English and Chinese. This was thought to enable better communication with both partners as well as the staff in the JV. However, despite his language advantage the general manager met great difficulty in managing the operation as his strong-western-style of management was unpopular with the employees of the JV. Behind it there was a "culture blockage": because he spoke Chinese and because of his identical Chinese appearance, he was not expected to use pure western management style by the local staff. As a result, he was unable to stimulate workers' enthusiasm and efforts and it led to the low working efficiency[9].

The situation has, however, improved as the joint operation moves forward. From a strategic point of view, the important point that both parties were aware of was how to justify the limited joint benefits that they have obtained with consideration of their long term objective.

7.4.4. Implication for valuing technology

On the basis of the assessment of technical sophistication, functionality, quality and cost, LESCO's machines fall into the category of upper-mid-level in terms of their specifications and unit prices in China. (machines involved in the collaborations in other case companies varies: e.g. GILLCO's machines in case D are in the category of upper level, MACHCO's machines in Case E are on the middle level while BIRMCO's machines in case F are in the same category of LESCO's machines). Chinese-made machines are assessed as the type of low level of specifications and prices. Therefore, the financial return from the joint operation is to be gained by a greater price premium and sales volume.

However, the Chinese machine tool market is very price sensitive. Competitors from Taiwan (such as YIRON), and US (such as HS) sold their machines at a low price which led to a fast increase of their market share in China. For example, YIRON sold its machining centres at US$25000 and lathes at US$18000 in the exhibition in Beijing in 1997 where LESCO lost 10 potential customers due to its price incompetitiveness. LESCO's machining centre made by the joint venture is currently sold at between US$96,000 and US$116,000 in China.

Faced with this price sensitive market, LESCO however chose not to turn to producing low cost machines. It believed that low cost thus low specification machines do not last long and that this type of machine very often starts to have problems after only a few years of usage. It was predicted that the users may likely change from being price driven to seeking high-tech and high quality.

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[9] LESCO realised the problem and the manager left at the end of year 1. Since then LESCO has been seeking a European to take the post and LESCO staff make regular visits to the JV (every two months) until the post is filled.

Nevertheless, more efforts are required to be made to reduce production cost. Local manufacturing is an effective means for cost reduction (it was calculated that 15% of production cost can be saved by localisation, and with saving from duty and transportation cost the total cost saving was expected to reach 30%). LESCO's original plan was to realise localisation up to 90% within 2 years (controllers may be sought from foreign suppliers in China) but this has been much delayed. So far, only assembly process has been localised.

The JV's management from LESCO side played a key role in determining the efficiency of operations which consequently influences value generation and realisation. The failure in management, together with other reasons such as market situation, caused a slow progress of the joint operation. JINSHA's original plan was to pay back all its capital investment within 4 years of the commencement of the operation. LESCO's revised plan was to sell 20 machines in year 1. None of these objectives has been met. Regarding technology valuation, the transfer value has not been as much generated as they expected in the three-year operation.

Nevertheless, as both partners pursue long term benefits and strategic development in local markets, the future value that are to be generated from the technology collaboration would be the major benefits to be sought. Thus the unsatisfactory returns so far achieved did not cause vital damage to continuing the collaboration. However, while seeking future value and long term strategic development, an emphasis needs to be placed on employing effective operational approaches in order to enhance the position for realising their joint objectives.

7.5 Case D: YANGZI Machine Tool Works and GILLCO UK

7.5.1 The context

7.5.1.1 YANGZI Machine Tool Works (YANGZI)

YANGZI was established in the 1940s and its original products were gear machines. The factory reshaped its product structure by placing more efforts to produce special machines in the 1980s. The intention was to capture the rapidly growing market for specialised machines and to take advantage of the accumulative technical expertise from its long history.

YANGZI has 1500 employees, of which 80% are involved in making machine tools. There are three types of product made by the company: gear processing machines, special purpose machine tools and nuclear reactor internals. 110 technicians are involved in development work (e.g. designing new types of machines), of which two thirds is on machine tools. The annual output value is RMB 60 million, of which CNC machines and exports take around 8% and 6% respectively.

YANGZI already had transfer experiences before the partnership with GILLCO UK. In 1988 it started a co-production agreement with PM (Italy) for a CNC boring and milling machine. The company made 25% of the machine parts and also undertook assembly and testing. Due to the expensive price there were only two orders in local markets. The company however built the third machine for its own use. The company had also established a co-production agreement in 1988 with KB (Germany) for a five-dimension vertical machining centre. The arrangement was the same as the one with PM. The situation of market demand was also similar. Three machines were produced and two sold, while the third was kept for YANGZI's own use.

7.5.1.2 GILLCO UK (GILLCO)

GILLCO is a subsidiary of GILLCO US - one of the largest machine tool companies in the world in terms of sales turnover of machine tools. The whole GILLCO has a very wide product portfolio. Products include special lathes, transfer lines, vertical and horizontal machining centres, gantry types of machines etc. It also makes its own CNC controls and PC controls. The company in the UK has 350 employees and is a manufacturer of special purpose machines with a worldwide reputation. Its major targeting market is the automotive sector. The annual output value is over £60 million. 50-60% of the total output are CNC machines and exports account for 60-70% of production.

GILLCO has been very successfully using its technological strength to improve the competitiveness of its production. In order to reduce lead time (a critical competitive factor for building special machines), GILLCO uses modular design to make 'modular style' components (i.e. make standard modules with modification for different special machines). Around 10 years ago each special machine was individually built but now all the special machines have 'uniformity', with standard parts such as stations and slide units. Each station can be used as an individual machine and, when linked with other stations, as a module in a transfer line (usually 5 stations form a line).

There is also a technique known as 'drop and ship' being used to reduce lead time. It means that individual modules are only assembled at the customer's plant rather than being assembled, tested and disassembled prior to delivery. Once a specialised machine is completed the whole production team for the machine helps customers install, commission and adjust etc. This technique was used for the CRSL's (US) order and reduced lead time to 8 months[10]. The company's next target is to reduce lead time to 6 months.

Being a global player, GILLCO sells its machines worldwide. Its sales in China are mainly through agents. To maintain efficiency, none of its agents is given exclusive rights to sell particular products. The number of its agents has grown to around 20 in China. In addition, considering the lack of knowledge of special machine tools by those agents GILLCO also opened its own technical service centre and sales office in Beijing.

7.5.2 Brief description of transfer arrangement: licensing agreement

- Year when contract signed: 1990
- Current status: terminated by the end of 1997
- Forms of collaboration: licensing agreement
- Technology type: special purpose
- Technology product: CNC transfer line
- Terms of payment: instalment plus 5% royalty. Instalment involved 4 stage payments:
  - 15% on signing contract 11/1990
  - 40% when the drawings had all been delivered 6/1992
  - 35% on completion of the first prototype 12/1993
  - 10% on completion of the project (i.e. on successful completion and delivery of the first commercial order)
- Transfer arrangement:

[10] Before the technique was used the approximate build timetable was 3 months for design, 3 months for parts production/sourcing, 3 months for build, and 3 months for test. The total is around 12 months.

- GILLCO: provision of drawings and training. Training included 100 man-months. 90 man-months of training in the UK were completed. The remaining 10 man-months of training were planned to be conducted in China when YANGZI gained orders.
- YANGZI manufacturing of the machines including machining parts and assembly based on the drawings. Selling machines in local markets and providing services to customers.

- Benefits gained:

- GILLCO obtained its commercial return from supplying technology (5% of royalties from future sales were intended but not received). It also gained access to information on customer requirements and local market development.
- YANGZI gained access to the technology to make a transfer line and would gain future returns from sales.

- Features of collaboration:

- There was no CKD assembly stage in the process of transferring technology for specialised machine tool. Parts were only supplied when requested. Purchase of drawings and training were directly followed by manufacturing by YANGZI. Joint name was not used for the machines, i.e. the end product based on the transferred technology, unless quality was approved by GILLCO.

- Due to the difference of specific features in each machine, a longer training period was provided (100 man-months). There was also special post-transfer technical support when the acquirer gains a customer order.

- Results:

- YANGZI has built 4 transfer lines in the collaboration, of which one was as a prototype and the other three were made to order. One was to make a special purpose machine include several FMC (flexible manufacturing cell) for producing transmission boxes for motorcycles. Due to the low selling price the company made a loss and the 5% royalty payment to GILLCO was not paid. Another project was to make a transfer line for transmission boxes for tractors. 19 machines were required to form 2 transfer lines. These two lines have not been completed by the time of late 1997 (note: the contract with GILLCO was due to end at the end of 1997). The company therefore cannot gain further orders as it does not have a good record of building such special purpose machines. GILLCO received no royalty payments from the collaboration.

7.5.3 Case analysis

7.5.3.1 Motivation

Even though the market for special purpose machines increased, YANGZI had difficulties in developing its market. For example, the company had experience of bidding for a contract for making a transfer line for Shanghai VW's transmission boxes, but failed due to its limited expertise in making such machines. Being aware that its weakness and poor reputation would prevent it from winning orders by itself, YANGZI had the intention to sign a transfer agreement with GILLCO in order to improve its capability to produce good quality machines for the automotive industry.

In GILLCO's view, automotive manufacturing is becoming globalised. GILLCO, as a leading special machine tool maker in the world, needs to serve its customers globally. Faced with the fast growing demand and increased foreign competition in the Chinese machine tool market, GILLCO decided not only to sell products in China but, and more importantly, to operate manufacturing in the local market.

In the course of seeking collaborative ventures in China, GILLCO initially did not intend to invest capital in China as this would require the permanent presence of GILLCO personnel in China for the control of the venture. GILLCO expected its contribution to be in the form of expertise, selling machines and support for customers. The favoured form of collaboration was through the sale of its intellectual property in the form of designs and training and meanwhile to gain royalty payments from the sales of products. More importantly, by establishing a presence in China GILLCO wished to locate itself strategically to benefit from the long term expansion of the automotive industry in response to the Chinese market potential and its future position in the global automotive industry.

As the major automotive companies mainly locate along or close to the east coast in China (e.g. Beijing Jeep with Cherokee, Shanghai VW, Shanghai GM, Citroen in Hubei with Dongfeng and Mitsubishi in Shenyang etc.), Shanghai was considered by GILLCO as the geographically best location for market development. The selection of YANGZI as the partner, apart from its good location where infrastructure was better developed, was also because of its large production capacity. GILLCO's idea was that, through collaboration, GILLCO's technology would contribute to improving its Chinese partner's product quality, and coupled with taking advantage of YANGZI's production capacity, good future market sales could be achieved.

7.5.3.2 Financial aspect

The price that YANGZI paid for the technology was US$1.2 million. Originally the price was US$ 1.5 million, by negotiations both sides made concessions: the supplier reduced the price while the acquirer agreed the payment rate in instalments in favour of the supplier. More specifically, the normal payment rate for license in four phases is: 10%, 35%, 40%, and 15% while in this case it was: 15%, 40%, 35% and 10% in each phase respectively. Apart from the contract price, YANGZI also incurred a large amount of consequential costs. These costs include purchasing foreign made machines for production and inspection and also building a new workshop specifically for this operation. The total consequential investment was RMB 40 million, nearly four times higher than the acquisition cost.

In YANGZI's previous transfer experiences with PM and KB, each co-made machine was US$ 200,000 less compared with an equivalent imported machine. Accordingly, YANGZI believed its collaboration with GILLCO would lead to a sizeable financial return. However in the case with GILLCO, the first machine took over 2 years to build. YANGZI made a loss on the project. This resulted from the low bidding price, which was made under pressure from competition, and some extra costs. The production of two transfer lines for the second project took even longer which again not only did not generate financial gains but also produced a bad effect on its reputation among customers. Due to the financial difficulty, the last 10% payment for the technology was not made, nor was the 5% royalty for selling the first machine paid to GILLCO. As a result there has been no future financial return achieved by GILLCO. Given that the amount of the royalty payment was calculated by considering the total technology (design and training) charges, estimated turnover and rate of return etc., GILLCO did not realise its financial target.

7.5.3.3 Technical aspect

The financial loss has a very high connection with technical failure in this case. The transferred technology was for the manufacture of a transfer line, for which, customisation and reliability are very important issues. Each application, and consequently each machine, is different and specialised skills such as sequencing of operations are crucial. Customers demand a guarantee of high reliability because module breaks-downs would cause the whole transfer line to stop. Both these issues require the manufacturer to have considerable 'know-how' about the whole manufacturing process. Such know-how however cannot be simply transferred via a sale of drawings and following build specifications, but, and more importantly, it requires a build-up of experience coupled with a good absorptive capacity. Such learning process critically needs a 'good circle': technology absorption is acquired from the experiences and experiences rely on technical success to win orders (to gain opportunity for the experience). However, YANGZI did not have the technological know-how for manufacturing such a special purpose machine and neither could it accumulate the necessary experience since it was unable to win orders from customers. On GILLCO's side, the intended technical benefit from the collaboration was to enlarge production capacity in order to respond to the fluctuation of market demand for special machine tools, and that was not achieved either due to YANGZI' inability to build good quality machines.

7.5.3.4. Strategic aspect

GILLCO's operations in China was carried out as a part of its overall strategy within the global context and it has a specifically strategic perspective towards Chinese market. There is specialisation in the automotive industry in Asia, for example, Thailand has a large truck-building capacity and Indonesia specialises in passenger cars, but China is strategically the most important to GILLCO as all types of vehicles (cars, motorbikes, buses and trucks) are built there. GILLCO's overall objective in China is to establish a strategic alliance and the licensing agreement with YANGZI was a part of its strategy.

YANGZI has also had an intention of strategic development through the collaboration with GILLCO but with more focus on enhancing its technological competence in local markets. The company is a member of the Shanghai Machine Tool Corporation which has a partnership with Shanghai Automotive Industrial Group. The link between the machine tool and the automotive groups provides access to major customers, therefore offering a good opportunity for developing local markets. Both parties' objectives were highly convergent in connection with market development.

However, the transfer of technology to YANGZI has not been successful for either side. The collaboration did not produce a good result regarding market development and strategic enhancement. YANGZI suffered from the experiences of failure in winning orders from customers on several occasions even with GILLCO's technology. There has been very little gain achieved from the collaboration with respect to strategic development. The strategic value from transferring technology to YANGZI was not generated and the possibility of capturing future returns was also shown to be low. The opportunity cost of missing market opportunities even led to a result of strategic 'disbenefit' from the collaboration considered by GILLCO. It therefore decided not to continue the collaboration with YANGZI when the contract ended in 1997.

7.5.4 Implication for valuing technology

From the unsuccessful experiences, both parties recognised that their low-commitment arrangement was not appropriate. This was an important lesson particularly for collaboration in making special purpose machines. For special machines, the acquirer cannot absorb the technology solely from the drawings and routine training. A learning-based experience is essential. An even greater problem was that the production of such special machines has to be based on customers' orders, whereas the acquirer did not have an advantage in market competition therefore the opportunity to gain experience was very limited. In addition, despite strategic expectations from both parties, the transfer agreement was based on low commitment which could only lead to a limited gains

In this case, winning orders was essential in both commercial and technical aspects, but in the process of bidding for orders, this relatively *looser* type partnership (licensing) showed its disadvantage. Their joint bidding failed because of a focus on clarifying each partner's responsibility of division of labour, instead of highlighting their joint strengths, which reduced the attraction to the customers. It was actually a reflection of the nature of this low commitment operation.

An even worse consequence was that some users, particularly JVs in the automotive industry in China, were suspicious of the quality of YANGZI's products. Hence they still prefer to buy foreign made machine tools, in spite of their higher price. In this situation, GILLCO's direct sales in China actually compete with YANGZI in the Chinese market.

An effective solution was to establish a *closer* partnership so that the collaboration could and should provide a phased programme of transfer with opportunities for the acquirer to gain experience in order to gradually absorb the technology. As GILLCO reviewed that the collaboration with YANGZI should be changed to that the supplier takes responsible for the manufacturing and marketing (winning orders) in particular in local market, the 'drop and ship' method would then be used to transfer the machines to YANGZI for the final assembly. GILLCO's benefit from such a closely committed arrangement would initially be a reduction in assembly cost, while YANGZI can be provided with more opportunity of gaining experience and improve technological understanding with GILLCO's support.

The actual involvement for the acquirer in this assumed co-production would depend on the number of customers' orders. If customers want a lower price machine, GILLCO and YANGZI can together finalise the parts that YANGZI is to make while GILLCO provides technical support. If customers want a machine made by GILLCO and are willing to pay the higher price, GILLCO would make the machine and YANGZI would only conduct the final assembly. This would enable the transfer process to be linked to the market success. Depending on customers' requirements, the more YANGZI is involved in production, the more know-how and skills can be learnt and the more cost can be reduced. Greater transfer value would be generated and shared between partners. Customers would also benefit as the price of the final product would be gradually reduced while maintaining product quality.

The case significantly suggests that the issue of technology valuation goes well beyond establishing the initial agreement on price. The transfer of technology only provided an *opportunity* to generate transfer value in the future. Both parties' benefits rely on future market sales while the result of market sales primarily depended on whether or not the acquirer was able to built such technically sophisticated machines. It clearly indicates that valuing technology is not a matter of setting up and negotiating a price but involves a decision about how to create and judge the potential value to each party.

7.6 Case E: BEIHAI Machinery Institute and MACHCO UK

7.6.1 The context

7.6.1.1 BEIHAI Machinery Institute (BEIHAI)

BEIHAI is not a traditional machine tool manufacturer. Originally it was a technical school, from 1969 to 1978 it was a manufacturer of machine tools and in 1978 became an institute. Being an institute, it has a higher proportion of engineers in the total number of employees. Among its 1200 employees, over 700 are engineers which includes 110 senior engineers. 20 senior engineers hold professional tittle which means the highest national level. Compared with many other Chinese machine tool manufacturers BEIHAI has stronger technical strength and also has more activities involved in R&D in its operation. It is a technologically based company.

The company comprises 10 divisions of which the NC machine tool division is a major part. The annual production is 50-60 NC or CNC machines and the output value is around RMB100 million.

BEIHAI has been focusing on new product development over the last decade, pursuing the latest technological development in the world and undertaking several operations in collaboration with foreign companies. Product technologies were acquired through various types of transfer arrangement and some end products have been successfully introduced into local markets.

The company has two aspects to its strategy: (a) to strengthen technological capability and (b) to commercialise technical advantage into the market. Pursuing these policies, the company has had several successful experiences of acquiring foreign technology and turning the technical enhancement into commercial yields. In its technology collaborations with foreign partners there were different products manufactured (not only machine tools). For example, in 1992 the company signed a co-production agreement with PILL (USA) to produce casting machinery. Sales turnover from this equipment has been US$5 million in two years and the investment was recovered in the first year. It was proposed to turn this agreement into a JV due to the commercial success.

These commercial achievements enabled BEIHAI to purchase US$ 20 million worth of whole production line equipment for manufacturing a CNC machining centre with its own capital in its collaboration with MACHCO. BEIHAI has a superior financial capability compared with most Chinese machine tool manufacturers, who normally require financial support from the government or bank loans when they import foreign technology or equipment.

7.6.1.2 MACHCO UK (MACHCO)

MACHCO US has a long history and world-wide reputation for its high quality machine tools. It was established in 1919. Turnover is around US$1 billion per annum, of which machine tools account for 40%. Other products are plastic moulding machines and tools etc. The company as a whole has a wide manufacturing base and MACHCO is a wholly owned subsidiary in the UK. MACHCO was established in 1934 and manufactured a wide range of products till 1980, when it became a 'focused factory' mainly making vertical machining centres.

MACHCO has around 400-500 employees in 1990s. Dramatically its annual output doubled within the four years from 1000 sets (1994) to 2000 sets (1998). The current annual turnover is around £100 million. 80% of output is exported to over 40 countries. The company therefore attained the Queen's Award for success in export markets in 1995.

The company believes that the key to success in competition is to stay in the forefront of new product development. MACHCO's objectives for new product development include: (a) to compete in the world market; (b) to offer competitive products; (c) to increase market share; (d) to improve productivity and (e) to ensure product quality. The features of its new product design are (a) to meet market needs and (b) to achieve efficient manufacturing. It has invested £3-4 million in high-tech development over the past 2 years. The company's products comprise three families of vertical CNC machining centres: *AW*, *SE* and *LR*. Each has specific features in terms of power, functionality, machining speed, accuracy, optional features and cost effectiveness etc. The SE range was developed first in 1989, followed by AW in 1993 and LR in 1995. There are no products designed before 1989 still in its production.

In addition, MACHCO developed a cost effective CNC turning centre. The machine was introduced into the market in early 1996 and within 4 months gained customers' orders covering two years (1996-1997) production. However, its product life cycle was only about two years. Since 1998, this range has been replaced with MACHCO's latest development of turning centre. Moreover, MACHCO also introduced a low cost and low specification vertical CNC machining centre in 1997.

Not only has MACHCO's new product technology been developed with a rapid pace but also its process technology has been improved dramatically. Its machines made in the early 90s took 600-700 hours to build and would be 'on the floor' for 8 to 10 weeks. At that time there were 1000 employees in MACHCO with an annual output of 300 sets. Now it only takes an average of 200-250 hours to build a machine which would be on the floor for 1 to 2 weeks. The annual output reached 2000 sets with around 400 employees.

25% of its exports go to Far East markets where China is perceived to have significant potential. As a corporation MACHCO as a whole started selling machines in China in the early 80s and has also established its sales office in Beijing. MACHCO commenced its sales of SE range machines in China in the early 90s with around 20 machines sold annually.

7.6.2 Brief description of transfer arrangement: co-production followed by JV

- Year when contract signed: 1992
- Current status: the first contract ended in 1997. Since then both parties have been negotiating a further collaboration.
- Forms of collaboration: first contract was co-production. The forthcoming contract will be a joint venture.
- Technology type: general purpose.
- Technology product: vertical CNC machining centre.
- Terms of payment for co-production agreement: instalment involved 4 stage payments. The total contract value was US$6 million comprising 110 machines. Payment was made at the beginning of each phase.
- Transfer arrangement:

  - MACHCO: provision of drawings and training on phased basis and supply of SKD/CKD kits and key parts. Training included a three-month training period in the UK involving 12 people of various disciplines. Training in the first phase was for technicians while the second phase was for members of the management team. MACHCO also provided training and supervision on electrical installation and application on BEIHAI's site.

- BEIHAI: manufacturing machines including machining parts and assembly based on the drawings. Selling machines in local market and providing services to customers.

• Benefits gained:

- MACHCO gained US$ 6 million of financial return from supplying technology and 110 machines. SE750 has been successfully sold in China. A satisfactory degree of localisation has been achieved so that the competitiveness of the machine is improved. MACHCO's strategic position in the Chinese market has been enhanced.
- BEIHAI absorbed the technology and developed its own vertical machining centre. From its successful sale it established a good reputation among local customers and has been appointed by the Bureau of Machinery of China as a key manufacturer producing CNC machining centre in China. BEIHAI also gained a good financial return from selling the co-produced machines.

• Features of collaboration: the co-production comprised 4 phases.

(i) Phase one - SKD assembly: 20 units of SKD kits supplied for subsequent assembly and testing by the Chinese partner. All components were imported from MACHCO.

(ii) Phase two - CKD assembly: 30 machines were supplied in CKD form for assembly without the need for expensive investment in tooling. Component imports from MACHCO were 90%. BEIHAI also started to assemble CNC control from this phase.

(iii) Phase three - co-production: 30 sets were shipped for assembly. Parts manufactured by BEIHAI were fitted. Component imports from MACHCO were planned to reduce down to 40% with CNC controls being locally sourced (imported from Japan). The import rate from MACHCO actually remained higher because the controls and drives, which were originally supplied by Fanuc, were replaced by the MACHCO's own CNC system (the system was MACHCO's new development).

(iv) Phase four - further localisation: 30 machines were built in China using locally sourced parts. Only critical items such as spindle carriers and tool changers were still supplied by MACHCO. Components import from MACHCO was only 25%.

- each stage was intended to last 6-8 months. The process however slowed down due to the problems in market sales. Phase 1 was started in April 1993 and the whole contract was not completed until late 1997 when all the 110 machines were sold. The whole period of the contract lasted about 4 years which was nearly two years longer than MACHCO's initial plan.

- Results: 110 machines have been sold and the co-production contract has been completed. An agreement for establishing a joint venture was reached and the contract proposal and feasibility study have also been approved by the government. It is currently (1999) in a stage of preparing documentation for the JV. The JV contract will be for 15 years. This is an equity joint venture and shares are divided into 60% for MACHCO and 40% for BEIHAI. Registered capital of the JV is US$ 3 million and there is no technology contribution in the equity. On the basis of co-production experiences there are no 'phases' of transfer required for the operation. Both parties expect the JV to move as rapidly as possible to local manufacturing.
- Under the JV agreements the roles that MACHCO and BEIHAI would play are as follows:

MACHCO	i) Partner in the JV.
	ii) Supplier of technology and limited key parts.
BEIHAI	i) Partner in the JV.
	ii) Supplier of majority of parts.
	iii) distributor of jointly made machines to the local market.
JV	Manufacturer of MACHCO's machining centres including 2 families and a number of models.

7.6.3 Case analysis

7.6.3.1 Motivation

MACHCO's initial objective for the collaboration was to establish a local presence in order to increase sales in the Chinese market. Due to the Chinese government's limitation on the direct import of low-tech types of machine it was apparent that there would need to be local participation to increase sales. In parallel, MACHCO also sought to exploit more local advantage to promote sales in China therefore a technology collaboration for manufacturing and selling SE machines was highly intended. With a view to establishing a collaboration in China, MACHCO, however, did not favour a JV at that stage, rather, it preferred for a few-years-contract for a technology transfer project.

BEIHAI was introduced to MACHCO by the CMTBA. Although BEIHAI only produced machines in small quantity it already had good production facilities and stronger technical strength compared with other alternatives. BEIHAI had three features which fitted MACHCO's criteria of selecting a partner:

i) The facilities were ideal and it had the right sort of environment in terms of staff and equipment (e.g. BEIHAI had the ability to produce a wide range of products and its way of producing machines was similar to MACHCO);

ii) There was a desire to become a profit making organisation and some achievements had been made; and

iii) It could raise the necessary funding to support the collaborative operation.

BEIHAI had a focus on development of its technological capability and had already experienced benefits from its previous technology transfers. Although a up-front payment was required, BEIHAI agreed to establish a co-production partnership with MACHCO. The incentive for BEIHAI to co-operate was to capture MACHCO's worldwide reputation for technology and product quality.

7.6.3.2 Financial aspect

In the first two years of the collaboration the financial return was low to both parties. By September 1995 when the contract started to enter the third stage, BEIHAI had only managed to sell 30 SE750 machines. According to the contract, BEIHAI then purchased another 30 machines from MACHCO with 20 still in stock. Although MACHCO gained the return from selling 80 machines to BEIHAI it did not see good future commercial benefits from the collaboration, taking into consideration of the contrast between China's large market size and BEIHAI's small sales. In MACHCO's view, BEIHAI's performance had been rather an institute-type than a firm-type in terms of their marketing approaches.

On the other hand, BEIHAI actually suffered much more than MACHCO as it bore all the costs and commercial risks due to its up-front payments for the purchase of machines at each stage. With a view to the unsatisfactory results of market sales there were some observations made by BEIHAI managers:

i) MACHCO's price for CKD kits was too high as it was nearly equal to the price for the ready-made machine sold to the local customers. There was only 9% difference but BEIHAI needed to pay the Custom duty while many direct imports for users were duty free. As a result the joint made machines did not have a price advantage.

ii) Due to this favourable policy for the imports by machine tool users, 1994 was the first year in China when the total import value of machines exceeded the annual output value of machine tool production. It was followed by 8% increase in imports in 1995. Facing severe competition from foreign machines it was the hardest time for domestically made machines in local markets.

iii) MACHCO only provided the SE750 model, while customers often required more than one model within a project (purchase). BEIHAI suggested that MACHCO offer more models in order to attract customers but this was not agreed by MACHCO.

To MACHCO, the limited and delayed commercial gains reduced confidence in future collaboration with BEIHAI. The value being realised from the transfer of technology was lower than MACHCO's expectation compared with its planned payoff period. MACHCO therefore doubted the strategic benefits from continuing to collaborate with BEIHAI. At one stage (late 1995) MACHCO determined that unless BEIHAI could produce convincing evidence of selling more products there would be no further collaboration between the two parties when the contract ended.

However, since 1996 BEIHAI's market sale has dramatically improved. At the beginning of 1996 BEIHAI changed its marketing strategy from selling single machine to focusing on designing production lines and therefore winning orders for complete sets of associated machines. By bidding, BEIHAI signed two projects which were for FMS for users in the automotive sector. The two FMS production lines comprised over 40 sets of SE750. As a result, the sales of SE750 reached the top as far as the sales of any individual brand of CNC machining centres were concerned in China. BEIHAI's sales of the machining centre accounted for 25% of total sales of domestically made same-type machines in Chinese market in that year. This method of selling the MACHCO machines continued its success in the following year and BEIHAI again achieved 25% of the market share among Chinese made CNC machining centres in 1997 (see Table 7.2).

Table 7.2 BEIHAI's sales of CNC vertical machining centres in the Chinese market between 1995-1997

Year	Total vertical CNC machining centre sold in China (sets)	Among total		Sold by BEIHAI	% of BEIHAI' sale in total sale of Chinese made same machines
		Imported	Chinese made		
1995	1500	1200	300	< 20	< 7%
1996	1700	1500	200	50	25%
1997	1200	1000	200	50	25%

Source: CMTBA and BEIHAI's sale figures

The improvement of market sale from BEIHAI not only yielded commercial benefits for both parties but the strategic significance of the collaboration has also been recognised by MACHCO. Negotiations for a further collaborative agreement were therefore initiated for establishing a longer term and more solid partnership.

7.6.3.3 Technical aspect

There were not many technical problems encountered in the process of transferring technology for making SE750. Within the first two years of collaboration BEIHAI effectively absorbed the know-how and skills, and based on it, it developed its own version of a vertical CNC machining centre. As a technology acquirer, BEIHAI has successfully achieved the technological objective: technology has been absorbed, the product has been upgraded, and a new product has been developed.

Furthermore, the collaboration also provided BEIHAI an opportunity to develop its technological potential in designing and manufacturing production lines for selling machines. Despite the common awareness of customers' increased requirement for the "tailor made" whole production line instead of individual machines (this is particularly true in the automotive industry) by the Chinese machine manufacturers, the majority of companies do not have a sufficient capability to complete such a "turn-key" project. The key capability was to design the whole production line to meet customer requirements, including machining units, auxiliary equipment, CNC system, parts conveyor line, process programming and tooling etc. which critically requires a comprehensive knowledge. BEIHAI effectively exploited and developed its technical advantage through its customised designing process, which can be regarded as a further technical benefits gained from the collaboration.

MACHCO was very satisfied with the quality of the end product made by its Chinese partner. In its assessment on *product feature performance* of BEIHAI made machines, all the features were rated *very satisfactory*. In the late stage of the collaboration, the production cost of the machine was reduced by around 20%, which gave the co-produced machine a certain price advantage compared with directly imported foreign machines. MACHCO's technical target has been basically realised although further cost reduction is still required.

7.6.3.4 Strategic aspect

From the initial arrangement MACHCO did not particularly seek long term benefits, rather, it focused on the medium term returns. The possibility of strategic development was considered by MACHCO but the further action was subject to the result of the initial contract. The strategic objectives were to enhance its position in the Chinese market including the improvement of product competitiveness and increase of market share. BEIHAI, on the other hand, had a stronger intention to obtain a long term development through the technology collaboration with MACHCO. One of the key elements in BEIHAI's strategic objectives was to improve and further develop its technological competence. The insufficiency of the initial arrangement in terms of limited transfer package, concerning updating know-how, range of product, scope of local manufacturing and marketing support etc., prevented both parties from generating and capturing greater strategic benefits.

Nevertheless, the improved market sale showed the strategic significance of further collaboration and therefore provided a strong incentive to both parties to establish a more solid partnership. The objective of operating a closer collaborative venture is to best exploit local advantages and strengthen joint forces so as to achieve greater mutual strategic benefits. In order to ensure more contributions are made to future development from their joint operation, the new collaboration arrangement was designed with more strategic considerations. Compared with the initial co-production arrangement the future operation contains the following features:

i) technology is to be updated with the latest development in the period of collaboration;

ii) product range expand to SE and AW including almost all the models within the ranges;

iii) more parts are to be locally manufactured;

iv) joint involvement in product design (e.g. BEIHAI will involve raising design issues and concept);

v) provision of experience learning of managerial knowledge; and

vi) the JV takes greater marketing responsibility and gains technical support from both partners.

These features would make greater contributions to their mutual strategic development. To MACHCO, its product competitiveness (e.g. performance to price ratio) would be further improved by using more local low-cost parts in built-machines, and also by the supply of various models of machine in the local market. To BEIHAI, more knowledge can be obtained and more experienced will be gained. These conditions and opportunities are critical factors in contributing to the development of its technological capability. Also the arrangement of updating technology is essential to narrow the technology gap. Both partners have high expectations of gaining mutual strategic benefits through their joint venture.

7.6.4 The implications for valuing technology

In the original co-production contract, to the supplier, its owner's value was realised on a phased basis as the acquirer made payments for the acquisition of technology by instalments. But even so, the supplier was not satisfied with the result due to the delay in achieving its commercial benefits. More importantly, it implied that little future value could be gained from the collaboration. To the acquirer, all the costs and risks were born by itself at each stage. With a view to the value of the technology, the acquirer assessed that the technology was valued on the high side. The reason of its acceptance was due to the acquirer's belief that a greater transfer value could be generated by the access to the worldwide reputation of the owner's technology. To achieve the target, the acquirer's technical capability was not seen as a handicap (contrast with Case D) but its inadequate marketing ability prevented it from receiving satisfactory financial value. At that stage both parties did not obtain as much benefit as expected. The supplier could not see the strategic value to be captured from the collaboration while the acquirer did even not gain enough financial return to cover its investment for the acquisition of the technology.

The case clearly shows that turning the technological advantages into commercial success is a key in valuing technology. The transfer value to the acquirer was firstly dependent on how the financial value was to be realised in the market. Technical value was well recognised and achieved at the early stage by the acquirer, but the added commercial value derived from this technical enhancement would still be in a *potential form* until it was realised in the market. By the same token, the strategic value was not recognised by either party until a satisfactory commercial result was produced.

A lesson has been drawn from the lack of commercial success of the earlier stage. The supplier realised that acquirer's marketing ability was equally as important as its technical capacity and should be regarded as a critical factor to the success of the collaboration. The new marketing strategy adopted by the acquirer, and the successful consequent result, demonstrated its significance. It was further identified that improving marketing strength may even not be isolated from the nature of the collaboration. With a looser commitment of the previous arrangement, MACHCO and BEIHAI in one bidding exercise actually acted as competitors. In that case, product competitions were between AW and SE, both were MACHCO's machines but were used by MACHCO and BEIHAI for the same bidding. The low commitment hence prevented both partners from taking advantage of their joint strength in market competitions. Another disadvantage in connection with the previous arrangement was that the provision of a single model of product (SE750) could not fully meet customers' requirements and hence was less attractive in winning orders. More importantly, technology was not effectively updated in the previous collaboration which led to some competitive disadvantage of their co-made product so that some market opportunities were lost, claimed by the acquirer.

Both parties recognised that a JV would provide a greater joint strength, not only increasing the technical value to both parties (e.g. improving acquirer's technological capability and further reducing production cost through an enlarged scope of co-production involving more ranges of machines) but also reinforcing product marketability so that the acquirer's advantage of designing production lines could be more effectively used. This would reflect that the collaboration arrangement can make a contribution to the value generation and realisation and also implies valuing technology should be taken as a dynamic process.

7.7 Case F: HUANGHE Machine Tool Works and BIRMCO

7.7.1 The context

7.7.1.1 HUANGHE Machine Tool Works (HUANGHE)

HUANGHE is a medium size machine tool company in China with 1500 employees. It is a specialised turning machine manufacturer. Similar to the situation of JINSHA Machine Company in case C, HUANGHE was originally from BOSEA Machine Tool Works and moved to Ningxia province as a separate factory in 1960s.

HUANGHE's major products include lathes, copying lathes and turning centres. Conventional and CNC machines each stand for about half of its output. HUANGHE's technical capability has achieved a great improvement in the past 30 years of its history. It currently produces the highest specification CNC lathes by Chinese standards. The quality of its machines and its customer service were given the top ranking in terms of customers' satisfaction in the domestic market. In 1997 it shared with another Chinese company to be granted a national best quality award for its CNC turning lathe (CK7815) by the Bureau of the Machinery in China. HUANGHE has captured 24% of the Chinese market for CNC turning machines.

HUANGHE has already had technology transfer experience with a Italian company to make a copying lathe. Although the machine was not CNC type, HUANGHE gained processing know-how of some key components and enlarged its product range from the transfer.

7.7.1.2 BIRMCO

The company originally produced conventional military weapons but from the early 1920s it started to manufacture machine tools. This is a private company and currently has about 100 employees. BIRMCO's major products are CNC single and multi-spindle automatic turning lathes and turning centres. Product ranges include the CHILL series of CNC lathes, the OMA range of turning centres and the STN range of CNC multi-slide automatic lathes which is newly developed based on its original WH range. BIRMCO focuses on producing high-tech and high-functionality hence high-value machine tools. The price of a machine tool made by BIRMCO (except STN range) is normally around US$0.5 million therefore the feature of its production is the high value of single unit with small quantities (different from Case E). The majority of BIRMCO's machines are customised products to meet customers' special needs. It is not a high volume production and a longer period of production cycle time is required compared with Case E. There are 39 models of machines and all are built to international quality standards. Its annual production output value reached £10 million in 1994.

The company started to sell machine tools in China from the mid 1980s. The approach used for sales was initially through the Hong Kong based trade agents. This was regarded as a cheaper way but not very effective, particularly for the special purpose machines. Since 1995, the MTTA's Beijing office became one of the major channels to provide Chinese customers' feedback to BIRMCO. It also takes part in itinerant seminars organised by the MTTA for introducing its products in China. In BIRMCO's view the best way of promoting sales in China in the longer term is to establish a partnership with a local company to exploit each party's complementary advantages.

7.7.2 Brief description of transfer arrangement: subcontracting and co-production

- Year when contract signed: 1997
- Current status: continuing
- Forms of collaboration: subcontracting and co-production
- Technology type: special purpose
- Technology product: STN CNC turning lathe and OMA turning centre
- Terms of payment: BIRMCO provided technology in the form of drawings free of charge. It in turn purchased carcasses supplied by HUANGHE at reduced cost and also will share the return from sales when HUANGHE sells co-produced machines in China.
- Transfer arrangement:

- BIRMCO: provision of drawings, training and technical supervision. Supplying key parts for making carcasses as *free issue* (i.e. no payment for these parts was involved). Responsible for final assembly on the basis of carcass and for selling products in the world market. Co-designing and developing other models of CNC turning lathe/centre with HUANGHE. Supplying key parts for co-developed machines which will be made completely by HUANGHE.

- HUANGHE: manufacturing parts, assembling carcasses and supplying the carcasses to BIRMCO. Co-designing and developing other models of CNC turning lathe and turning centre. Building these co-designed machines in the complete form. Selling these co-developed machines in local market.

- Benefits gained:

- The costs of production and design in BIRMCO were reduced. It made a substantial contribution to BIRMCO's competing price for its machines (STN range) which had a price disadvantage before the collaboration. A commercial benefit from sales was also gained.

- HUANGHE has acquired part of the technology for design and building a CNC turning lathe and turning centre. The methods for quality control in process planning and production management were also learnt. The commercial benefits were obtained through the supply of carcasses to BIRMCO and returns from the future sales in the local market are also expected.

- Features of collaboration:

- Transfer process was set into 4 phases:

i) In phase one machines were built to complete by BIRMCO with their carcasses made and supplied by HUANGHE. BIRMCO sells machines in its worldwide market.

ii) In phase two BIRMCO and HUANGHE co-design and co-develop new versions of STN and OMA machines.

iii) In phase three the prototypes of complete machine are made by HUANGHE.

iv) In phase four, carcasses of the newly developed/modified machines are made by HUANGHE for supply to BIRMCO and complete machines are made by HUANGHE for sale in the local market.

- Training and technical support are provide by BIRMCO in each phase. Four HUANGHE's engineers have completed one month training in BIRMCO for phase one. Training for phase three is planned to take place in March 2000.

- Results: The first batch of five carcasses (supplied to BIRMCO by HUANGHE) have consequently been built to completed machines and all have been sold. The second batch of five carcasses have arrived at BIRMCO. The third batch is also ordered by BIRMCO. Co-design and development of new versions of machines are in progress. A prototype of complete machine is started to build by HUANGHE for the local market.

7.7.3 Case analysis

7.7.3.1 Motivation

BIRMCO was attracted by the Chinese market potential and low cost advantage. The main reasons for BIRMCO to establish a direct business link in China were stated as follows:

i) There is a large market potential. China has already shown an increased demand for machine tools in recent years and it is predicted that the market growth will continue.

ii) The most buoyant market in China is the automotive industry which is one of BIRMCO's major user sectors.

iii) No firm can sell products and obtain local customers' information effectively if too far away from the market (e.g. only through sales agents);

iv) There are fewer manufacturers for making some parts of machine tools in Europe while in China those parts are manufactured in many companies and can be produced at lower costs;

v) BIRMCO has a willingness to transfer technology into China and help Chinese partners to improve their technological capability so that they will be able to manufacture good quality parts as subcontractors of BIRMCO.

The objective for HUANGHE in this collaboration with BIRMCO was to obtain the advanced technology which is critically required for making the high-tech machines. In terms of technological capability improvement, HUANGHE's target from the collaboration was to enable it to produce a complete high-specification CNC turning lathe and turning centre. BIRMCO's objective on the other hand was to improve its product competitiveness by combining technological and cost advantages. The collaboration would enable BIRMCO to achieve a greater cost reduction in manufacturing machines and new product development. From a long-term strategic point of view the competitive strength of their co-developed product, coupled with high-tech and low cost, would have a significant impact on enhancing their positions in both local and world markets.

7.7.3.2 Financial aspects

The collaboration arrangement has been designed to ensure that there is an immediate financial benefit to both parties. In many technology transfer based collaboration arrangements, the acquiring partners have suffered financially because of their inadequate marketing skills and lack of experiences of selling more expensive co-produced machines in local markets. This in fact has become one of the main causes of failure of many collaborative ventures (e.g. Cases B and C). BIRMCO recognised that converting technological success into commercial results could be problematic, so from the start the company gave first priority to the issue of market sales. In phase one BIRMCO was fully responsible for the sale of products in all markets by taking advantage of its established name and reputation throughout the world. Additionally, by sourcing materials (parts and machine carcasses) at lower cost, greater commercial benefits could be derived through either increased sales by offering lower prices or by maintaining prices and selling at higher margins. Meanwhile, HUANGHE also achieved its commercial objectives by supplying carcasses to BIRMCO rather than trying to sell finished machines in the competitive market. Equally important, the subcontracting arrangement did not incur significant extra costs to HUANGHE because it already had sufficient expertise to manufacture the sub-contracted parts and the assembly skills to build carcasses. BIRMCO and HUANGHE also shared the product development costs and future profits from sales when the newly developed products are introduced into the market, thereby ensuring a financially equitable arrangement in the process.

7.7.3.3 Technical aspects

The substantial technical benefit for BIRMCO was in terms of cost reduction. There were three aspects of the collaboration from which this can be derived:

(i) The purchase of carcasses from HUANGHE which would otherwise be manufactured by BIRMCO at higher cost.

(ii) The purchase of other parts from HUANGHE which otherwise would be supplied by subcontractors at higher cost.

(iii) The effective use of HUANGHE's expertise for co-design and co-development.

HUANGHE on the other hand obtains advanced knowledge and skills in the following ways:

(i) by gaining process programming know-how and acquiring assembly know-how and skills from the process planning, build specifications and training.
(ii) by acquiring product design and development expertise from drawings provided by BIRMCO, co-design and co-development exercises and BIRMCO's technical support.
(iii) by gathering quality control and production management knowledge through training and phased project planning.

BIRMCO recognised that the key technical issue of cost reduction is how to maintain the quality while reducing costs. It therefore considered effective transfer measures to facilitate the learning and experience accumulation process for HUANGHE, so that the cost reduction would be coupled with maintaining quality. To do so, BIRMCO changed from the normal way of reducing cost through technology collaboration, that normally starts with the acquirer's involvement in the CKD kits final assembly (de Bruijn and Jia, 1993a; Zhen, 1987), to that HUANGHE only focused on machining parts and mechanical subassembly. In this way HUANGHE's low cost advantage could be used while the end-quality of machines was still controlled by BIRMCO. This was followed in subsequent phases by focusing on carcass built to final assembly of the complete machine. In the process, training was provided to allow problems to be revealed and solved effectively. Once there is sufficient understanding of the product/technology, further cost reductions will be achieved through co-design and co-development. Meanwhile, extending the scope of components to be manufactured by HUANGHE can further reduce the cost. The practice of cost reduction even included bought-out parts and commercial parts, provided HUANGHE can succeed in finding qualified local suppliers, good quality parts and suitable low cost materials. The maximum scope for cost reduction will be achieved with product quality being maintained throughout the whole transfer and collaboration process.

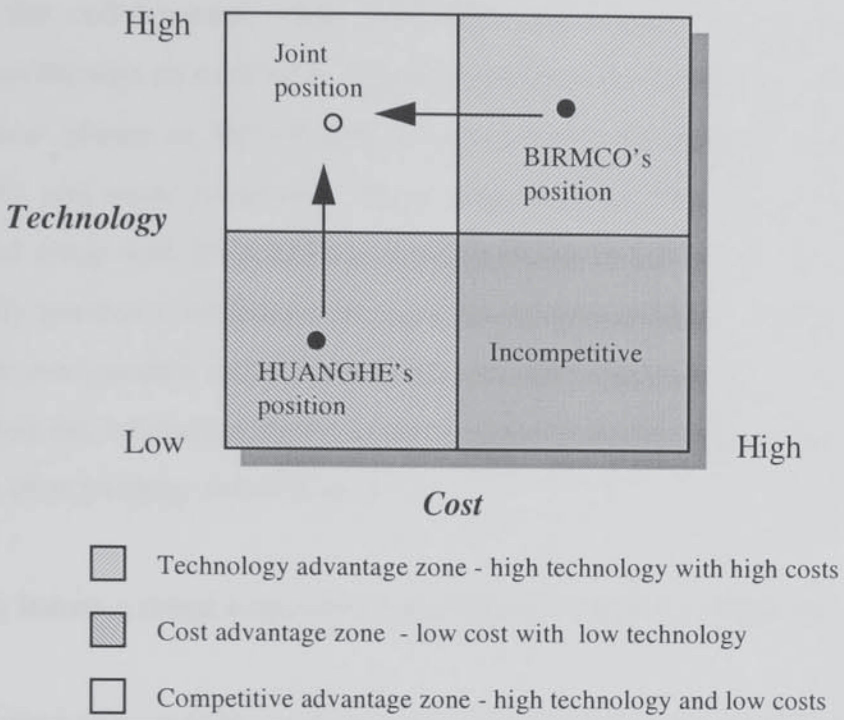
7.7.3.4 Strategic aspects

The coverage of transferred product/technology is a key factor in market success in the machine tool sector. It means that the segments of product, local source and market, in which the technology suppliers and acquirers intend to involve, need to be strategically identified (O'Brien, 1987). In this collaboration, different types of machines were specified for the UK and Chinese local market. The coverage of transferred technology and local sources being capitalised for each type of machines also differ to achieve best use of the joint advantage. The overall strategic benefits to BIRMCO derived from its opportunity of exploiting the commercial potential of its technology by reducing cost, increasing sales in existing markets and developing new markets. It also benefited from the complementary knowledge of HUANGHE when co-designing and co-developing the new products. On the other hand, HUANGHE gained access to the leading edge technology for the specific products, thereby enabling it to optimise its future product development. In addition, one range of machines (STN) being chosen for the collaboration was a low unit-price type compared with the other ranges in BIRMCO's product portfolio. The strategic benefit for both partners would be derived from the opportunity to develop a highly competitive new machine range in terms of performance to price ratio, and consequently to create a new niche in both the world and Chinese markets.

7.7.4 Implication for valuing technology

The collaboration was fundamentally based on the enhancement of joint competitive strength. BIRMCO and HUANGHE have, respectively, the benefits of technological and cost advantage. Moreover, each one's respective advantage was the other's disadvantage. By jointly using their complementary advantages they can achieve a competitive position that would otherwise be out of reach of each partner on its own (see Figure 7.1). In line with this strategy the collaboration arrangement placed emphasis on how best to employ each party's advantage along with its capability for improvement so as to achieve sustainable enhancement of joint competitiveness.

Figure 7.1 Enhancement of joint competitive strength through exploitation of complementary advantages



Overall, BIRMCO's and HUANGHE's objectives were well matched but the question arose of how to guide the collaboration towards realising mutual transfer objectives. To ensure the realisation of both parties' objectives the collaboration arrangement between BIRMCO and HUANGHE was designed as a comprehensive package. The key feature of the arrangement was to effectively link cost reduction practice with the technology transfer and learning process. In other words, costs were progressively reduced while technology is being gradually transferred. Cost reduction targets and transfer targets run in parallel throughout each phase, so that further cost reductions can be achieved along with an improvement in the acquirer's technological capability. The co-design and co-development of the new product was the thread linking together cost reduction practice and the transfer process and, based on this aspect, a new product featuring with high technology and low cost is to be developed.

In the collaboration process, the commercial, technical and strategic value of technology may not be realised simultaneously, so a phased co-ordination of these achievements is required. In this collaboration the arrangement was made to ensure a "win-win" situation for both parties, capturing commercial value first. Learning the lesson that market failure was caused by an acquirer's lack of technical competitiveness and marketing competence, the collaboration was set-up to exploit only each party's existing competitive advantage at the initial stage. HUANGHE's financial value can be guaranteed by supplying machine carcasses to BIRMCO within the collaboration, while BIRMCO can achieve its financial value from selling machines through its worldwide distribution channels. Technical value was obtained through subsequent phases as HUANGHE acquired more technological know-how by undertaking assembly and more processing. Meanwhile, BIRMCO's cost reduction target was further achieved along with HUANGHE's capability improvement. Finally, strategic value will be gradually generated and achieved from their joint strength that enables a new high technology and low cost product to be developed and a new market niche to be established. The case illustrated the interaction of financial, technical and strategic achievements along with the process of technology collaboration.

7.8 Key Issues Arising From The Cases On Technology Valuation

7.8.1 Enhancement of the opportunity to realise mutual transfer objectives

The realisation of mutual transfer objectives has been seen as the key for collaboration to success. From the above cases it is shown that both suppliers and acquirers sought market development. To gain entry to the Chinese market, suppliers transferred their technology and acquirers obtained know-how and skills to enable them to further develop the market. However, suppliers may retain some key know-how as long as the market can be accessed and/or the cost reduction objective is achieved. In such cases acquirers may not have access to adequate knowledge for effectively improving their technological capability. This problem was encountered in case B so the acquirer's technical enhancement was limited. It in turn led to a failure to achieve an adequate return from the market with consequently neither of the two parties' objectives being realised. On the other hand, Case F demonstrates a good example in that the effort was made by both parties to enhance the opportunity to realise mutual transfer objectives. Being provided with adequate technical know-how and marketing support, the acquirer in case F was able to capture future returns, therefore it greatly appreciated the value of technology. In comparison, the transfer value of technology in case B was assessed lower by the acquirer as the know-how it obtained was inadequate to achieve its transfer objective.

7.8.2 Use of effective transfer measures to facilitate the learning and experience accumulation process

Transfer value is the return that acquirers can gain in the future from technology acquisition hence it would depend on the acquirers' ability to absorb the technology. Transfer value may not be realised if the acquirers are unable to effectively absorb and use the technology even with the key know-how being provided. Therefore appropriate measures are required to facilitate the learning process so as to assist acquirers with effective absorption of technology. The transfer arrangement was inadequate to help the acquirer to absorb highly sophisticated technology in case D. The acquirer suffered market failure from technical difficulty in learning and experience accumulation. The result was neither the supplier nor the acquirer obtained the transfer value. By contrast, the transfer arrangement in case F provided the acquirer with sufficient opportunities to learn know-how and to gain experiences, enabling the acquirer to effectively use those knowledge and skills. Transfer value has been generated and shared between the two parties.

When collaboration involves sophisticated technology in the production process, communication between the parties is critical to the efficiency of the operation. Without good communication, errors in production and maintenance can occur (Si and Bruton, 1999). This was found to be very true from the case studies. The almost daily communication made in case F, has been recognised as a critical contributory factor to solving technical problems efficiently and to monitoring the operation against the planned schedule effectively. Beyond that, frequent communication has also been found significantly important to maintain each party's confidence with their collaboration and to reshape the arrangement as necessary to meet the frequent changes of market opportunities.

7.8.3 Sharing return based on each party's capable contribution to generating joint benefits

The value of technology that both parties can accept is an indication of how the future value is to be shared between the two parties. To identify each party's contribution towards generating future joint benefits is the means by which over- or under-valuing of the technology can be avoided. Arguments on the value between technology suppliers and acquirers are often due to inadequate assessment of each party's ability to contribute to the value added exercise. In cases B and D the acquirers' technical capabilities and marketing skills were over estimated initially by both suppliers and acquirers themselves. The future value that was generated and gained by each party was actually much less than initially expected. The arrangements for their collaboration were reviewed to be inappropriate to create best joint strength on the basis of the acquirers' existing capabilities. Greater value may otherwise be generated if acquirers' potential can be more effectively developed with adequate support from suppliers. By contrast, Cases A and F demonstrate the benefits to both sides that derived from the appropriate assessment of each others capability, hence the suitable arrangements which ensured an effective use of each complementary strength was established. As a result, they shared returns according to each side's contributions to the added value. The value of technology was therefore acceptable to both partners.

Table 7.3 provides a summary of the major factors (regardless of capital investments) being used from each party in contribution to generating and realising the joint benefits in the collaboration. The majority of factors in cases A, E and F were competitive, hence the satisfactory return have been generated and realised. Consequently each party shared the joint return based on its contributions. Suppliers in cases A and F shared relatively higher percentage of benefits as they involved more in manufacturing and hence made greater contributions to generating the return (regardless suppliers' returns from their capital shares in cases C and E). In cases B, and D, the process of generating and realising the joint benefits mainly involved in the acquirers' activities. Because the poorer results of their absorption of transferred technology and their unsatisfactory marketing capabilities, the expected returns were not generated hence nor have the satisfactory shares of return been achieved. In case C, the acquirer's poorer marketing capability has been as a handicap to the realisation of the joint benefits.

Table 7.3 Summary of the major factors being used in contribution to generating and realising the joint benefits in the collaboration

Contributory factors	Case studies					
	A	B	C	D	E	F
Competitiveness of supplier's technology	H	H	H	H	H	H
Supplier's manufacturing capability	G	-	-	-	-	G
Supplier's marketing capability	-	-	-	-	-	G
Acquirer's absorption of transferred technology	G	P	G	P	G	G
Acquirer's marketing capability	G	P	P	P	G	*

Notes: 'H' refers high. 'G' refers to good. 'P' refers to poorer than expectation. '-' means not being used in the process of generating and realising the joint benefits. * In case F, acquirer's marketing capability will be used in phase four.

7.8.4 Turning technical enhancement into commercial success

Transfer value should reflect the returns which both suppliers and acquirers expect to gain. Fairly satisfactory commercial gains were achieved in case A, which encouraged the collaboration to continue. However, the value of technology is only realised in the market while in cases B, C, D and E (at early stage), the acquirers experienced difficulties when selling their co-made products in markets. It in turn became one of the main causes of failure in technology collaborations as reflected in cases B and D. It is seen that to convert the technological enhancement into commercial benefits was a problematic area. The commercial result was even further reviewed as an indicator of the strategic importance from the collaboration. As shown in case E, the turning point to continue the partnership was when the acquirer changed its marketing strategy to dramatically improve its market sales. Otherwise it would not be strategically sensible for the further collaboration from the supplier's point of view. Case F was the only example in which the issue of market sale was given the first priority to be considered from the beginning. The supplier was well aware that the technical enhancement (derived from collaboration) would be valueless until it was proved in the market. The commercial value was sought as an immediate return by both parties to ensure the value of technology as well as the significance of the collaboration. On the basis of that, the technical value and strategic value were gradually achieved and would lead to a subsequent increase of commercial value in the future. A case comparison of the features used to achieve commercial gains and the effects of the financial return on the collaboration is summarised in Table 7.4.

Table 7.4 Case comparison of the features used to achieve commercial gains and the effects of the financial return on the collaboration

Features adopted to achieve commercial gains and the effects	***Case Studies*** A		B		C		D		E		F	
	Sup	Acq	Sup	Acq	Sup	Acq	Sup	Acq	Sup	Acq	Sup	Acq
Features												
Use of the supplier's world distribution channel											√	
Suppliers to win orders in the local market			*				*					
Marketing of customised product with supplier's support	√	√					*				*	
Acquirer's own activities in sales		√		√		√		√		√		
Effects												
Financial return against expectations	S	S	U	U	U	U	U	U	U/S	U/S	S	S
Impact of financial return on the continuity of collaboration	P	P	N	-	-	-	N	-	N/P	-/P	P	P

Notes: '√' means the feature was adopted in the process of collaboration. '*' means the importance of the feature was realised and was intended to use in the future (not necessarily in the collaboration in question). 'S' means satisfactory. 'U' means unsatisfactory. 'U/S' means unsatisfactory in early stages but satisfactory in further stages. 'P' means positive impacts. 'N' means negative impacts. 'N/P' means negative impacts in early stage but positive in further stages. '-' means seeking improvement in the future despite of unsatisfactory financial achievement.

7.8.5 Establishing appropriate collaboration arrangements to smooth the transfer process

All the cases showed that the collaboration arrangement has a substantial impact on technology valuation. It is because valuing technology comprises the process of value generating, capturing and sharing. During the process, each side's benefits, costs and risks are compared and on the basis of that the value judgement is made against its objectives. All these results depend on how the arrangement is made to compose the joint strength, to clarify the contributions (of each party), to control and monitor the operations, to share the benefits, costs and risks, and to ensure the achievement of mutual objectives.

Case F noticeably demonstrates that on the basis of agreement it requires continuous efforts and flexibility to make collaboration work. Technical communication occurred on an almost daily basis in the first year of transfer, as provision of training and drawings was insufficient to ensure the acquirers fully understood the very technical details. Meanwhile, there was also flexibility around the agreement during the process of collaboration. The scope and dimensions of their collaboration has been enlarged with more acquirer's activities being involved in the operation. Co-design and co-development of new models of machines were beyond the original agreement but it has so far been working well. It actually tied up the relationship closer and really brought both partners to work together.

The successful factors highlighted and lessons drawn from the above cases demonstrate the important role that the collaboration arrangement played in the process of technology valuation (see Table 7.5).

Table 7.5 Summary of the features in collaboration arrangements from cases

Arrangement features	Case studies					
	A	B	C	D	E	F
Effective use of partners' complementary strength	+	-	-	-	+	+
Updating the transferred technology	+				-, +	+
Adequate technical support & learning process	+	-	+	-	+	+
Market-oriented/adjusted transfer package	+	-	-	-	- , +	+
Appropriate operation management			-			+
Supportive sharing arrangement or commitment	+	-	+	-	+	+

Notes: '+' refers to *appropriate arrangement made and good effects achieved.* '-' refers to *inappropriate arrangement made and bad effect caused.* '-, +' means *inappropriate in the first collaboration and appropriate in the following collaboration.* The blank cell stands for *not in the case* and/or *no effect from it.*

Table 7.5 reflects the importance of collaboration arrangement on the consequent good or bad effects. These effects subsequently influenced the actual value achievements in each collaboration (see Table 7.6). With appropriate arrangements and their subsequent good effects in cases A, E and F, a greater return was achieved and satisfied both parties. By contrast, the unsuitable arrangements in cases B and D caused an unsatisfactory result which eventually ended their collaborations. In between, case C had mixed features and effects from its arrangement. The achievement has been behind the planned target, however, the solid commitment of both parties should ensure that the collaboration will continue for the long term development.

Table 7.6 Summary of actual value achievement in the cases

Means by which benefits were achieved	*Case Studies* A		B		C		D		E		F	
	Sup	Acq	Sup	Acq	Sup	Acq	Sup	Acq	Sup	Acq	Sup	Acq
Financial value	H	H	L	L	L	L	L	L	H	H	M	M
Initial charge			√				√					
Instalment									√			
Royalties			√		√		√					
Supply of parts/carcasses			√									√
Buyback discount											√	
Share of return	√	√		√	√	√		√	√	√	√	√
Technical value	H	H	L	M	L	M	L	M	M	H	H	H
New product		√		√		√		√		√		√
Key know-how gained		√								√		√
Cost greatly reduced	√								√		√	
Quality improved		√								√		√
Strategic value	H	H	L	L	h	h	L	L	H	H	H	h
Market access gained	√		√		√		√		√		√	
Sales increased	√	√							√	√	√	√
Position enhanced	√	√							√	√	√	
Competence fit*		√								√		

Notes: 'H', 'M', 'L' refer to high, medium and low in value achievements, and 'h' means perceived high, from the supplier's and acquirers' assessments. '√' refers to the means by which to gain the value achievement. * Competence fit refers to marketing know-how/skills and operations management improvement.

7.8.6 A summary: valuing technology cannot be isolated from the context of specific collaboration arrangements

Table 7.7 presents a summary of the characteristics of all the cases selected in this chapter. The suppliers' motivations for transfer comprised increase of sales, market development and developing local suppliers to supply low cost components for building machines. The acquirers' motivations focused on technological development including upgrading products, improving quality and capability enhancement. The financial, technical and strategic benefits were considered by both parties. The financial benefits were found to rely heavily on (a) the immediate quality improvement, which was however substantially influenced by the effectiveness of technology transfer, and (b) the acquirers' capability to develop market. In cases B and D, unsatisfactory technical improvement were basic reason for their poor market sales, while in cases A, E and F, marketing capability were essential, although different approaches were adopted in each case. In case C, the delayed process, to certain extent, not only implied the market problems/difficulties, but also highlighted the importance of the management issue as well as working relationship between partners. All the cases indicated that the future strategic benefits have consequently been affected by the financial and technical achievements. The interactions between financial gains, technical improvement and strategic enhancement were also shown in all cases.

The case studies revealed the complexity of technology valuation processes in which collaboration arrangements were seen to carry a considerable impact on the value. The extent to which technical strength actually enhanced from received technology attributes, hence the results of value generation varied depending on the collaboration context in which arrangements were specifically formulated and operations were undertaken accordingly. All the cases clearly showed that valuing technology cannot be isolated from the specific collaboration arrangement. The next chapter will summarise all the identified issues, based on the evidence from the cases and surveys, and develop a valuation framework under the context of a collaboration arrangement.

Table 7.7 Summary of case features

	Cases					
	A	B	C	D	E	F
Motivation	•Supplier - access to local market •Acquirer - effective means of technological development	•Supplier - develop a new market •Acquirer - upgrade technological level of products and develop a new product	•Supplier - seek long term market development •Acquirer - make high quality products	•Supplier - capture fast growing market, a part of global strategy •Acquirer - need high technology to develop market	•Supplier - increase sales by local production •Acquirer - capture supplier's reputation for high technology and product	•Supplier - use local advantage to reduce cost •Acquirer - obtain technology to develop new high-tech products
Financial aspect	•Acquirer's reputation for producing gantry milling machines helped to win orders	•Insufficient commercial gains	•Delayed process caused lower return and higher cost	•Larger consequential cost •Poor market sales	•Single model and high CKD cost caused low sales •Winning orders by designing production line	•Commercial gains were ensured by buyback arrangement
Technical aspect	•Experienced •Updated equipment •Low consequential cost	•No experience •Key know-how not transferred •Cost reduction not achieved	•Slow progress in transfer of technology and localisation	•Inadequate technical support •Failure to gain experience	•Development of a new product and acquirers' technical potential in designing production line	•Phased transfer and new product co-development led to an effective learning
Strategic aspect	•Use complementary strength to make greater joint contribution	•Neither market nor acquirer's technical capability have been developed as expected	•Unsuitable management •Inefficient coordination	•High opportunity cost of missing market opportunities	•Financial and technical achievement led to establish a strategic alliance	•Development of local component supplier, low cost and high-tech new products, and new markets
Implications for valuing technology	•Share returns based on each party's contributions	•Objective divergence: acquiring high-tech vs cost reduction. •Value not fully appreciated	•Seek greater future value •Keep price premium	•Unsuitability of arrangement for sophisticated technology transfer	•Enlarge the scope of using complementary advantages	•Interaction and coordination of financial, technical and strategic value
Case summary	•Sharing financial return based on each party's capable contribution to generating joint benefits	•The unsatisfactory joint benefits cooled enthusiasm for further collaboration	•High commitment requiring mutual trust, deep understanding and appropriate approach of management	•Low commitment leading to a technical incapability which inhibited market sales	•The key to collaboration development is to convert technological strength into commercial success	•A well designed collaboration arrangement to ensure both partners' objectives achieved

CHAPTER EIGHT
VALUING TECHNOLOGY WITHIN THE CONTEXT OF TECHNOLOGY COLLABORATION

8.1 Introduction

So far the basic value components, owner's value and transfer value, have been discussed, and the related factors affecting value have been identified and assessed. The terms of transfer payment and features associated with specific forms of collaboration and their impacts on the value of technology have been explored. The case studies exhibited key issues in varying aspects from which their implications for technology valuation have also been highlighted. Further to these steps, this chapter combines all the related elements (identified from the research surveys and case studies) to explore how technology is valued within the context of technology collaboration. The discussions focus on the following main aspects:

(i) defining the objectives for technology transfer
(ii) assessing contributory factors to realising transfer objectives
(iii) measuring technology attributes
(iv) determining value in financial, technical and strategic dimensions.

On this basis, a conceptual framework of technology valuation is developed.

8.2 Defining The Objectives For Technology Transfer

8.2.1 Assessment of convergence of transfer objectives between two parties

The progress made so far in this study has demonstrated that technology valuation requires a broader consideration including financial, technical and strategic aspects in which technology can make a contribution to achieving the objectives that both suppliers and acquirers formulated for the transfer. Case studies showed that all the transfer activities and efforts made were guided by the objectives, and suggested that the degree of transfer success or failure was evaluated against the extent to which the transfer objectives had been realised.

Objectives provide direction, create synergy and reveal priorities (David, 1995). Based on the case studies, Table 8.1 shows that the objectives of both suppliers and acquirers include commercial, technical and strategic considerations, although each side may have different specific objectives within each aspect.

Table 8.1 Suppliers' and acquirers' major objectives for technology transfer from their experience

	Suppliers' objectives	Acquirers' objectives
Financial objectives	• Access to local market • Increased sales in local market	• Increased sales in local market • Sales to external markets
Technical objectives	• Cost reduction • Alternative use of technology	• Upgrading technological level of the product • Improved quality of product • Development of technical capability
Strategic objectives	• Market share and strategic position enhancement in local market • Development of local supply chain	• Technological competitiveness enhancement in local industry • Access to the world market

Source: The UK and Chinese machine tool case studies

A successful collaboration basically only results from a commitment leading to the realisation of both parties' objectives, hence it is essential that both parties' objectives are matched. From Table 8.1 it is seen that some objectives are convergent (e.g. increase of local market sale from both parties); some may lead to convergence in the future (e.g. development of local supply chain from suppliers and access to the world market from acquirers) and some may, however, not appear to converge (e.g. technical objectives between the two sides). In the latter case, a further clarification of objectives may be required and specific transfer arrangements and operational measures may also be taken to ensure that the collaboration is developed to satisfy both parties (e.g. see case E in Chapter 7).

Matching objectives between two parties can affect the result of a collaboration enormously. As the case studies showed, a different degree of match may produce a great disparity in transfer content, collaboration efficiency and the total joint gains. For example, Case A in Chapter 7 shows that, based on the convergent objectives (increasing domestic market sales together with co-developing a new product), the complementary advantages from each party were effectively exploited in their collaboration. Local market sales were increased along with the transfer of technology and the acquirer's technological development. It in turn created a new opportunity for both parties to collaborate on a further level. In case D, on the other hand, the divergence of objectives led to a lower commitment collaboration (a licensing agreement) which proved to be inadequate compared with the sophistication of the technology (a co-production arrangement was realised to be more appropriate by the supplier afterwards). In this case, the supplier's objective for market entry by an alternative use of its technology did not commit itself putting sufficient efforts into this external operation (e.g. inadequate technical and marketing supports). The acquirer's capability failed in efficient improvement without obtaining adequate technical support from the supplier. The vicious circle, which was: inefficient absorption of technology - poor quality of end product - inability to win orders from customers - losing the opportunity of learning know-how and experience accumulation, was seen as an inevitable result of this inappropriate collaboration arrangement.

It has shown, from case studies, that a high convergence of objectives resulted in joint efforts in the same direction and led to the realisation of both parties' objectives. In comparison, divergent objectives were unlikely to contribute to the establishment of an adequate arrangement in which the objectives of both parties could be satisfactorily achieved. The value of technology was consequently thought as mis-judged by either party.

8.2.2 Assessment of the importance of transfer objectives

A further consideration is that within the overall transfer objectives, each specific objective may have a different weight of importance depending on the priority of what suppliers and acquirers intend to achieve through the collaboration (see Table 8.2). The differences in importance indicate each party may give more consideration in realising their more important objectives at different stages of development. Consequently they may give higher value to the technology which could make more contribution to realising these priorities (objectives). As shown in Table 8.2, the technology which could best serve the purpose of providing market entry or increasing market sale and improving technological capability would be more appreciated by suppliers and acquirers respectively.

Table 8.2 The relative importance of objectives for technology transfer from suppliers' and acquirers' prospects

Assessment of the importance of suppliers' objectives	*Importance* (sum=100%)	Assessment of the importance of acquirers' objectives	*Importance* (sum=100%)
Market entry or increased sales	29%	Improving technological capability	28%
Enhancement of strategic position locally	28%	Long-term strategic development	25%
Reduction in production costs	24%	Increased domestic market sale	24%
Acquisition of low cost local components	19%	Gaining access to the world market	23%

Source: The UK and Chinese machine tool surveys

The case studies also show that the priority of objectives did have an impact on the valuation of technology. In cases B and E in Chapter 7, both of the suppliers regarded market sales as the most important objective for their collaborations, while the objective of strategic position enhancement was taken as equally important as market sales by the supplier in case E but considered of much less importance by the supplier in case B. In the assessment of the value of their technology, the results of market sales were shown to be the most important criteria. However, because of their different perspectives relating to the importance of their strategic development in the local market, the suppliers in each case undertook different measures when their objectives of market sales were not met, i.e. the expected value of technologies was not fully captured. The supplier in case B, in the end, changed its strategy from an on-going technology collaboration to one-off transaction by selling machines to realise the value of its technology. In such a way the value of its technology is only realised at the current worth but no share of future transfer value is involved. The supplier in case E, on the other hand, with a view to its strategic enhancement in the local market, dealt with difficulties in market sales in a phased-progressive approach and eventually established a further collaboration arrangement to meet the two main objectives. As such , a greater future value is expected to be captured and shared. These cases demonstrate the importance of matching objectives and meeting priorities in technology valuation within a context of collaboration.

8.2.3 Matching objectives and their implications for technology valuation

The above analysis suggests that the matching assessment should include not only the convergence of overall objectives between each party, but also the relative importance of the specific convergent objectives to each side's priorities. The variety of overall matching situations is illustrated in Figure 8.1.

Figure 8.1 Assessment of convergence and importance of objectives between suppliers and acquirers

Convergence of objectives	Importance of objectives: High	Medium	Low
High	(1) High convergence and importance	(2) High convergence medium importance	(3) High convergence low importance
Medium	(4) Medium convergence high importance	(5) Medium convergence and importance	(6) Medium convergence low importance
Low	(7) Low convergence high importance	(8) Low convergence medium importance	(9) Low convergence and importance

Position (1): *High convergence and high importance.* This indicates that both parties' objectives are well matched and the collaboration has an important implication to each side. The joint value is perceived high so both partners would believe that they will be mutually better off through a collaboration. The value of technology may be fully appreciated (e.g. the proposed further collaboration in Case E in Chapter 7).

Position (2): *High convergence and medium importance.* Both parties recognise that either side would gain benefit from a collaboration therefore are willing to establish a partnership. The value of technology can also be highly appreciated by the acquirer particularly when the majority of the return to the supplier is through the sharing of future value (e.g. Case A in Chapter 7).

Position (3): *High convergence and low importance.* Although there is high convergence on their objectives neither party has a strong willingness to closely commit itself to such a collaboration where a low significant future return or unimportant implication for future development is perceived. The value may be established at low level in a one-off transaction.

Position (4): *Medium convergence and high importance*. It is a typical situation shown in many experiences. The matching of important transfer objectives encourages a partnership to be established. However, an effective operational approach must be in place for a collaboration with such a feature (medium convergence of objectives) to ensure both objectives are realised. A phased co-ordination of commercial, technical and strategic interactions between the two partners is essential for such collaborations to work. Hence a greater joint value can be generated and more solid collaboration can also be developed in the future (e.g. Case F in Chapter 7).

Position (5): *Medium convergence and importance*. Neither side is very certain about how much future mutual benefit can be generated. Suppliers would normally prefer to gain a sizeable immediate return to avoid future uncertainty. Acquirers also only allocate limited resources into this type of arrangement. The value can be accepted by acquirers in the form of a major amount of initial value plus limited future return to suppliers, provided the initial acquisition cost is not too high. It seems a suitable solution and in fact it is often the typical case for transferring technology through a licensing agreement (e.g. Case B in Chapter 7).

Position (6): *Medium convergence and low importance*. There would be a very limited intention for either party to accept a sharing arrangement of future benefits. The initial value is specifically preferred by suppliers whereas acquirers may not be willing to commit much investment into it. There may not be a transfer transaction at all.

Position (7): *Low convergence and high importance*. The potential value is perceived high but in a limited aspect to either side. As there is a large divergence regarding their objectives the mutual benefits may not be achieved. It is difficult to establish the value of technology that is acceptable to both sides. There is often an implication under such a situation that the product/technology is not suitable and/or the potential partner's capacities do not well fit. Therefore alternative partners need to be considered.

In position (8) and (9), similar results are likely to occur as in position (7) and/or (6).

To summarise, in positions (1), (2), (4) and (5), as the convergence and importance of objectives are at high/medium level the mutual benefits from technology collaboration are more clearly perceived than in others. An on-going joint commitment is therefore expected with an aim at realising a greater value of technology. In the rest of the positions, due to the divergence/low importance of objectives, the value of technology that is acceptable to both parties may not be established.

Objective assessment provides an indication of the overall situation where the value of technology can possibly be established. However, the intention to realise mutual objectives does not necessarily guarantee that the target can be achieved. The next step is thereby to identify what factors make a contribution to realising the transfer objectives.

8.3 Assessing Contributory Factors For Realising Transfer Objectives

The realisation of transfer objectives relies on the factors that contribute to this achievement in a technology collaboration. Following Porter's (1985) general assessment of competitive advantages, these contributory factors stem from three main sources:

(i) The competitive strength of suppliers and acquirers, such as their capability to undertake technological development, or to meet customers' specific requirements, as well as reputation of their product and distribution channels etc.;

(ii) The features of the product, such as technological level, newness of design, quality standard, product range and price competitiveness etc. (these can also be regarded as features of product technology);

(iii) The features of process technology, such as process efficiency, built-in quality assurance measure, cost effectiveness and superior performance etc.

For technology valuation it is a critical step to identify: a) what are the key contributory factors in connection with realising transfer objectives and b) what contributory factors can be obtained/enhanced through technology collaboration. Table 8.3 gives an example of the assessment of the importance of the technical contributory factors for realising one of the acquirers' technical objectives - technological capability development. It implies that given the importance of each contributory factor, acquirers would appreciate, to a greater extent, the value of technology that may bring more benefits in enhancing their capability of product design, quality improvement and manufacturing.

Table 8.3 The importance of contributory factors for acquirers' technological capability development

Contributory factor	Relative importance of factor for improving technological capability
• Product design (advanced & customised)	29%
• Product quality & quality control	21%
• Response time and manufacturing time	18%
• Process planning and tooling	9%
• Costing control	9%
• Production capability	8%
• Product ranges	6%
Total	100%

Source: The Chinese machine tool survey

The capability improvement resulting from technology acquisition can be reflected in the raised strength of related contributory factors. The enhancement of these contributory factors suggests a greater contribution can be made to realising the acquirer's transfer objectives (Bennett *et al*, 1999a). Two criteria of these contributory factors need to be considered: the degree of importance and the extent of enhancement. The significance of assessing the importance is not only for identifying the key contributors but also for judging the technology gap by positioning acquirers themselves in terms of their relative technical strength or weakness of each factor. Factors with a higher degree of importance but weaker in the acquirers' existing strength would be the bottleneck where the improvement is most required. Such improvements, as perceived transfer benefits, would be of greatest value and more appreciated by the acquirers in technology valuation.

8.4 Assessing Technology Attributes

Given that there has been an assessment of transfer objectives and contributory factors, the value of acquired technology would be based on the extent to which these objectives and factors could be enhanced. As discussed in Chapter 5, Table 5.2 has shown that foreign machines provide greater satisfaction in meeting customers' requirements in all quality elements. Table 5.6 further revealed a high positive relationship between superior product performance and greater objective achievement on the basis of the machine tool users' assessment. Hence, for product improvement, acquirers would expect imported technology to provide attributes that would contribute to higher performance and better quality with improved efficiency. Have the Chinese machine tool manufacturers obtained such technology attributes from their acquisition of foreign technology? Compared with Chinese machines,

Table 8.4 shows Chinese machine tool users' appraisal of the performance improvement for technology transfer based Chinese machines based on their experience.

Table 8.4 Comparison of product features performance between Chinese made machines based on transferred technology (TT) and local technology

Contributory factors for improving product performance	General purpose machine			Special purpose machine		
	TT based (1)	Local tech (2)	Difference in satisfaction (3) = (1)-(2)	TT based (4)	Local tech (5)	Difference in satisfaction (6) = (4) - (5)
Functionality	6.75	5.25	1.50	8.40	6.33	2.07
Reliability	6.50	4.63	1.87	8.20	5.83	2.37
Accuracy	6.63	5.38	1.25	8.40	8.00	0.40
Ease of use & maintenance	6.38	6.25	0.13	7.80	7.80	0
Consistency	6.63	4.75	1.88	8.20	6.00	2.20
Processing productivity	6.50	5.50	1.00	8.20	6.30	1.90
Appearance	5.63	4.50	1.13	7.60	6.00	1.60

Source: The Chinese machine tool user survey

Columns (3) and (6) in Table 8.4 highlight the extent to which the attributes of transferred technology have contributed to improving the product performance of the technology-transfer based machines. These improvements, despite having different extents to each feature, have been recognised by Chinese machine tool users, and hence raised their satisfaction. Considering the high correlation relationship between superior product performance and price premium as assessed in Chapter 5, the technology attributes for realising acquirers' objective of increasing sales revenue can be further recognised.

As technology attributes are the reflection of superior know-how and skills, acquirers can also assess the contributions from acquisition of such know-how and skill to improving their capability (Bennett *et al*, 1999c). This could help acquirers to better understand the features of technology and hence enable them to make an appropriate judgement of its value. However, suppliers would also measure the attributes of their technology but with different criteria (referring to Table 4.2). When suppliers and acquirers share similar perceptions of technology attributes, the value of technology can be established with mutual acceptance. When there is a gap between suppliers' and acquirers' perceptions of value it reflects a divergent view of the importance of attributes of know-how and skills between the two sides, as discussed in Chapter 5 (referring to Figure 5.4 and Table 5.12).

It should be noted, however, when technology attributes are assessed higher by one party while lower by the other, it may also imply that there is an unsuitability of technology/product, capability of partners, forms of collaboration, or availability of competing technology in markets. The alternatives need to be considered by both sides in such circumstances.

8.5 Valuing Technology In Three Dimensions

8.5.1 Three value dimensions

Given that the transfer objectives, contributory factors and technology attributes are considered, the rule in determining forms of collaboration that both suppliers and acquirers need to consider is that a collaboration arrangement should be established in such a form whereby most of the contributory factors can be strengthened, and technology attributes can be effectively captured and best exploited. On this basis, the technology can be valued considering all financial, technical and strategic dimensions.

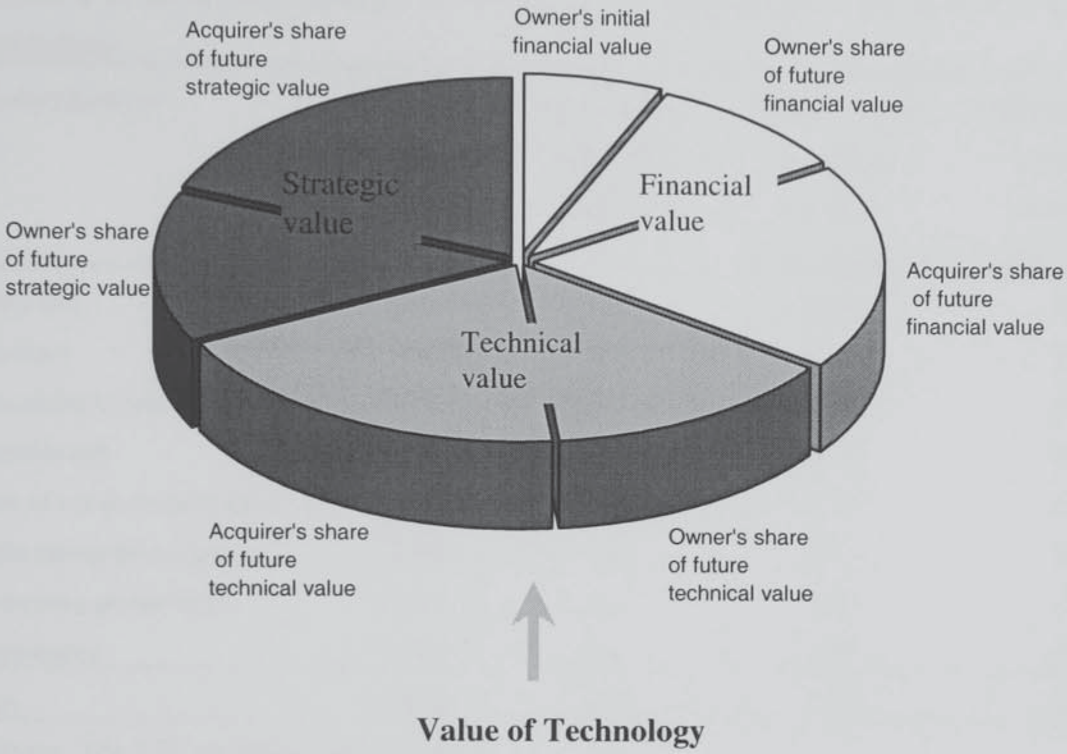
Financial value can be directly reflected from sales revenue. The technology owner's sales revenue includes either the return from 'selling' its technology or the shared return from sales of end product or both. Therefore, the owner's financial value comprises a) initial value, which is the up-front payment made by acquirers for the acquisition of technology, and b) the shared future value that the owner wishes to capture from future generated value. To the acquirer, on the other hand, the revenue only derives from the sales of the end product resulting from the transferred technology. Acquirers gain their financial value through sharing future value with the owners when a sharing arrangement is involved in the collaboration.

Technical value reflects technical improvements such as new product development capability, customised designing capability, manufacturing capacity, cost effective and good quality product etc. Technical value can only be generated in the process of technology collaboration therefore, for suppliers, it has to be achieved through the sharing of future value. The elements of technical value may be different between suppliers and acquirers depending on their technical objectives and the types of collaboration arrangements being established.

Strategic value refers to strategic achievement including market position enhancement for further development, established company's reputation and product image, developed distribution channels, increased local market shares and access to new markets etc. The generation of strategic value is a long term process so neither suppliers nor acquirers can capture it at the initial stage of collaboration. Sharing of the future value is required for both partners to obtain strategic value.

In summary, financial value is a direct indicator of return while technical value and strategic value are essential to an increased and sustainable financial value in the future. Value in the three dimensions would all be relevant and share importance in technology valuation (see Figure 8.2)

Figure 8.2 The three value dimensions in technology valuation



Value in the three dimensions are all parts of the value of technology but value in each dimension may be captured at different phases and may also weigh differently in the targeted gains of suppliers and acquirers. To attract an appropriate collaboration arrangement and to establish an acceptable value for both parties, a balance of sharing value among different dimensions is required.

8.5.2 Establishing links among the three value dimensions

Financial value is easy to represent as profits from sales but it is more difficult to measure technical and strategic value in direct financial terms. Despite some technical and strategic value components being quantifiable because of their direct links to financial returns, such as reduction of costs and increase of market shares etc., there are many other technical and strategic benefits which cannot be quantified such as improved capabilities and product brand value (Cravens, 1994). For technology valuation, it is crucial to develop a means by which the technical and strategic value can be measured through their contributions to generating greater financial returns.

For this purpose, the technical and strategic strengths that would enhance financial value need to be studied. Table 8.5 exhibits an example of measuring the actual technical value in terms of product quality improvement and its contribution to the increase of financial value through market sales from the UK companies' experiences.

Table 8.5 Suppliers' assessment of their technology attributes in contributing to improving the quality of technology transfer based products by comparing the actual results against their expectations

Product features	Assessed importance (1)	Actual obtained technology attribute (2)	Weighted actual technology attribute (3)= (1)x(2)	Weighted obtained technology contribution (4)= % of (3)
Reliability	14.4%	2.3	0.33	12%
Accuracy	14.0%	3.0	0.42	16%
Processing consistency	12.8%	2.7	0.34	13%
Functionality	12.5%	3.0	0.37	14%
Ease of use and maintenance	12.2%	3.0	0.37	14%
Performance price ratio	11.7%	2.3	0.27	10%
Processing productivity	11.5%	2.7	0.31	12%
Appearance	10.9%	2.3	0.25	9%
Sum	100%	21.3	2.67	100%

Source: The UK machine tool survey

Notes:

- The technology attribute is obtained at an average 44% = total actual obtained attributes (21.3) ÷ complete attributes that technology can provide (48*).
- *The score of 48 stands for the total technology attributes = fully satisfactory result for each product feature improvement (6) x number of features (8)
- The technology attribute is obtained at weighted average 45% (= 2.67 ÷ 6)
  Weighted actual contribution of product quality to sales = 45% x 37%[11] = 16.7%

The sum of column (2) demonstrates that, according to the suppliers' assessment, the total attributes actually obtained by their partners (acquirers) stood only for 44% of the complete acquisition. The weighted obtained attributes in the column (3) were based on column (2) but took into account the differences in importance of improving quality among product features. Column (4) shows the distribution of total technology contribution to improving quality in each specific feature. The weighted contribution to improving reliability was achieved (12%)

[11] 37% is the weight of contribution from *product quality*, among other major factors, to realising the local market sales objective assessed by the acquirers from Chinese machine tool survey results.

less than its importance weight (14.4%) which seems to be the most unsatisfactory result. The technology contribution to realising the market sales objective through improving product design and quality (by enhancing the respective product features) was not fully achieved. The quality attribute in contributing to raising market sale was actually made lower (16.7%) than assessed (37%). The market sales, as a result, were worse than expected because of a lower degree of satisfaction with end product quality.

Despite the lower degree of technology contribution actually obtained than the expectations to raising market sales, Table 8.5 does illustrate a linkage between a function of technology (improving product quality) and its financial return (market sales). By measuring the contributions of the functions derived from the technology transfer to the future financial added value, the links between three value dimensions can be established (more details of converting technical/strategic value into financial terms see section 8.6.3).

8.6 Technology Valuation Framework Development: Establishing The Value of Technology

So far all the factors affecting value within the context of technology collaboration have been assessed in this study. The assessment provided a basis to establish the concept that valuing technology is a dynamic process of value generation hence the future value is a particularly significant variable to be considered. On this basis, a framework for technology valuation to provide criteria to judge, and a tool to build, the conditions where the best value can be achieved is required. The aim of the framework is to help both suppliers and acquirers to build a solution to the following three basic questions which were found fundamental and inevitable in establishing value from all the cases:

- Is it worth transferring/acquiring technology at all?
- Is it the best value that can be achieved in the intended collaboration arrangement?
- How much is the best value worth?

In order to respond to each question, the following measures need to be taken consecutively. The value of technology would be established when a satisfactory or acceptable and step-by-step result is achieved.

(i) Measure the value of technology based on the VA concept to evaluate whether it is worth transferring or acquiring technology; and based on it,

(ii) Measure the value index to judge whether it is the best value obtainable; and finally,

(iii) Measure the total value by incorporating the returns in all three value dimensions into financial terms to determine how much the best value is worth.

8.6.1 Value analysis: is it worth transferring/acquiring technology at all?

As mentioned in Chapter 2, in general VA terms, value is defined as the ratio of function to cost. The maximum value is achieved when the essential function is obtained at minimum cost. For the value of technology, it more specifically refers to the ratio between the acquired technology contribution (as function) and associated cost, i.e.

$$\text{Value} = \frac{\text{Obtained enhancement from technology and collaboration}}{\text{Cost}} \qquad (8.1)$$

Referring to the assessment of transfer objectives, contributory factors and technology attributes so far, and also regarding risk as a reduction of attribute acquisition, the above formula can be developed as:

$$\text{Value} = \sum \frac{\text{Importance of contributory factors}^{1} \text{ x tech \& transfer attributes}^{2} \text{ x (1-risk rate)}^{3}}{\text{Costs}} \qquad (8.2)$$

or

$$= \sum \frac{\text{Importance of contributory factors x pre-TT strength}^{4} \text{ x (1 + \% of enhancement}^{5}\text{)}}{\text{Costs}} \qquad (8.3)$$

Notes:

[1] *Contributory factors* include all the related factors which contribute to realising specific transfer objective.

[2] *Technology & transfer attribute* is measured by rating the contribution (of enhancement) that technology & collaboration can make to improving corresponding contributory factors.

[3] *Technology & transfer attributes (1-risk rate)* = actual obtained attributes, which may have variation from the assessed technology contribution depending on risk rate.

[4] *Pre-TT strength* stands for the capability before the technology transfer.

[5] *Pre-TT strength* x *(1+ % of enhancement)* refers to the expected technology/transfer attributes to be obtained taking into account possible reduction due to risks.

Based on formula (8.3), the following formulas of financial value (V_f), technical value (V_t) and strategic value (V_s) reflect value in each dimension.

8.6.1.1 Financial value - is it financially worth transferring/acquiring technology?

To judge the financial value is to measure the contribution of technology to realising the financial objective. The financial objective is often concerned with local market sales. The related contributory factors included in the formula, as examples, are based on the suppliers' and acquirers' assessments in the UK and Chinese questionnaire surveys respectively.

$\mathbf{V}_{f\ (1)}$ = sum of [each factor enhancement relating to realising its financial objective / each corresponding cost]

$$= \sum \frac{\text{Contributory factor importance x pre-TT strength x (1+ \% of enhancement)}}{\text{Corresponding cost}}$$

= $\sum$ {[importance of technical level of product x pre-TT level x (1+ % of improvement) / cost] +
[importance of product quality x pre-TT quality x (1+ % of improvement) / cost] +
[importance of performance price ratio x pre-TT ratio x (1+ % of improvement) / cost] +
[importance of product range x pre-TT range x (1+ % of enlargement) / cost] +
[importance of production capacity x pre-TT capacity x (1+ % increase) / cost] +
[importance of delivery time x pre-TT minimum time x (1+ % reduction) / cost] +
[importance of after sale service x pre-TT service x (1+ % of improvement) / cost] +
[importance of distribution channel x pre-TT channel x (1+ % of development) / cost]}

$V_{f(1)}$ is established for the situation when each corresponding cost can be identified to obtain the enhancement of the related contributory factors for greater gains from technology transfer. In some cases however there might be difficulties in distinguishing each corresponding cost that are related to obtaining a specific transfer benefit. $V_{f(2)}$ is an alternative formula (see below), which is established for the situation when the corresponding cost cannot be distinguished to acquire the related factor enhancement. The choice of formula should be made according to the suppliers' and acquirers' real situation.

$\mathbf{V}_{f\ (2)}$ = [sum of factor enhancements relating to realising the financial objective] / [sum of associated costs]

$$= \frac{\sum \text{[Contributory factor importance x pre-TT strength x (1+ \% of enhancement)]}}{\sum \text{[Associated costs]}}$$

8.6.1.2 Technical value - is it technically worth transferring/acquiring technology?

The technical objectives often are divergent between suppliers and acquirers in the broad context of technology transfer. From the case study evidence the suppliers' technical objective is often concerned with cost reduction while the acquirers' objective is to improve their technological capability.

To the supplier:

$\mathbf{V}\boldsymbol{t}_{(1)}$ = sum of [each factor enhancement relating to realising its technical objective / each corresponding cost]

$$= \sum \frac{\text{Contributory factor importance x pre-TT strength x (1+ \% of enhancement)}}{\text{Corresponding cost}}$$

= $\sum$ {[importance of development cost x pre-TT level x (1+ % of reduction) / cost] +
[importance of machining cost x pre-TT level x (1+ % of reduction) / cost] +
[importance of subassembly cost pre-TT level x (1+ % of reduction) / cost] +
[importance of final assembly cost x pre-TT level x (1+ % of reduction) / cost] +
[importance of material cost x pre-TT level x (1+ % of reduction) / cost] +
[importance of delivery cost x pre-TT level x (1+ % of reduction) / cost] +
[importance of overhead cost x pre-TT level x (1+ % of reduction) / cost] +
[importance of marketing cost x pre-TT level x (1+ % of reduction) / cost]}

Or: $\mathbf{V}\boldsymbol{t}_{(2)}$ = [sum of factor enhancement relating to realising the technical objective] / [sum of associated cost]

To the acquirer, the factors being mainly considered may be different from the suppliers. For improving their technological capability:

$$\mathbf{V}\boldsymbol{t}_{(1)} = \sum \frac{\text{Contributory factor importance x pre-TT strength x (1+ \% of enhancement)}}{\text{Corresponding cost}}$$

= $\sum$ {[importance of product quality x pre-TT quality x (1+ % of improvement) / cost] +
[importance of quality control x pre-TT method x (1+ % of improvement) / cost] +
[importance of design ability x pre-TT ability x (1+ % of improvement) /cost] +
[importance of response time to customers x pre-TT time x (1+ % of reduction) / cost] +
[importance of product technological level x pre-TT level x (1+ % of improvement) /cost] +
[importance of programming ability x pre-TT ability x (1+ % of improvement) / cost] +
[importance of costing control x pre-TT method x (1+ % of improvement) / cost] +
[importance of production capacity x pre-TT capacity x (1+ % of improvement) / cost]}

Or: $\mathbf{V}\boldsymbol{t}_{(2)}$ accordingly.

8.6.1.3 Strategic value - is it strategically worth transferring/acquiring technology?

The long term strategic objectives are normally convergent between partners. To both suppliers and acquirers the strategic objectives are mainly to enhance position of long term development in the local market. However there are some factors specifically relating to each side due to the difference in their future benefits.

To the supplier:

$\mathbf{V}_{s\ (1)}$ = sum of [each factor enhancement relating to realising strategic objective / each corresponding cost]

$$= \sum \frac{\text{Contributory factor importance x pre-TT strength x (1+ \% of enhancement)}}{\text{Corresponding cost}}$$

= $\sum$ {[importance of company's reputation x pre-TT awareness x (1+ %of improvement) /cost] +
[importance of market share x pre-TT share x (1+ % of increase) / cost] +
[importance of product competitiveness x pre-TT level x (1+ % of improvement) / cost] +
[importance of profitability x pre-TT level x (1+ % of increase) / cost] +
[importance of local supply chain x pre-TT situation x (1+ % of development) / cost]}

Or: $\mathbf{V}_{s\ (2)}$ = [sum of factor enhancement relating to realising strategic objective] / [sum of associated cost]

To the acquirer:

$\mathbf{V}_{s\ (1)}$ = $\sum$ {[importance of company's reputation x pre-TT awareness x (1+ %of improvement) /cost] +
[importance of product competitiveness x pre-TT level x (1+ % of improvement) / cost] +
[importance of market share x pre-TT share x (1+ % of increase) / cost] +
[importance of profitability x pre-TT level x (1+ % of increase) / cost] +
[importance of CNC m/c tool export x pre-TT export x (1+ % of increase) / cost]}

Or: $\mathbf{V}_{s\ (2)}$ accordingly.

The means by which the value of technology is measured would enable both suppliers and acquirers to appreciate the input to output ratio explicitly in all financial, technical and strategic dimensions. Among the alternatives (technologies, potential partners and collaborations), the value with the higher ratio should be considered as a priority. The judgement of its worth can then be made by comparing the perceived value and its implication with suppliers' and acquirers' expected improvement.

Given that the value reflects the relationship between obtained transfer benefits and associated costs, it however does not indicate whether it is the best value that can be achieved through technology collaboration. To establish an effective transfer arrangement so that the best value (a greater benefit at relatively lower cost) can be achieved, the next step is to assess the value index.

8.6.2 Value index improvement: is it the best value that can be achieved?

8.6.2.1 Establishing the value index

There are always costs involved for the provision of functions. In VA terms, the value index is defined as the ratio between the importance of the function and the percentage of the corresponding cost to deliver, or to acquire, such a function.

For the purpose of technology valuation the value index is to show the relationship of percentage (or importance) between the obtained technology/transfer attributes and the associated costs. On the basis of assessing the technology contribution to realising transfer objectives and identifying corresponding costs associated with the transfer, the value index of technology can be established by using the following generic formula. The specific value index in financial, technical and strategic dimensions can then be established by incorporating related elements accordingly (more details see Appendix A).

$$\text{Value index} = \frac{\text{Percentage of weighted technology contribution}^{1}}{\text{Percentage of costs}^{2}}$$

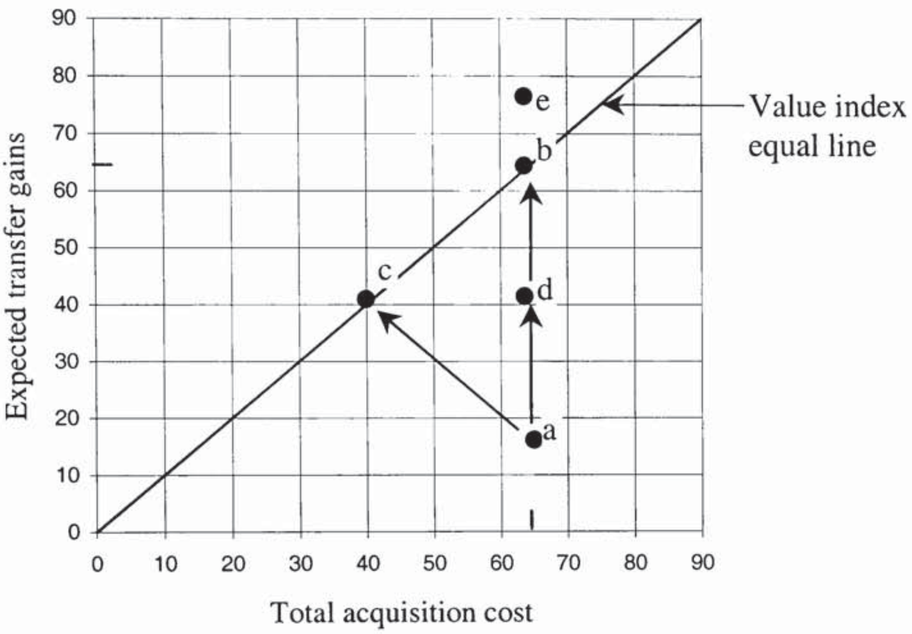
Notes:

[1] Refers to the expected percentage of a specific technology contribution in the total contributions derived from technology transfer taking into account its importance in realising the transfer objective.
[2] Refers to the percentage of costs (within the total cost) associated with obtaining the specific technology contribution.

8.6.2.2 Improving the value index

In the example of Table 8.5, if the cost incurred in relation to improving quality were less than 16.7% of the total cost, the value index of obtaining such attributes would be greater than one. It means this cost element is effective in generating benefits. The result of less than one would imply that technology was ineffectively transferred, absorbed and used. This suggests that in order to establish the value of technology accepted by both suppliers and acquirers, the value indices should not be below the equal line (see Figure 8.3) for both sides. It means that the value of technology would be at least accepted anywhere along the value index equal line depending on the scale of transfer investment. Given a specific total cost (investment) required for a technology acquisition and the expected future return derived from the transfer, the sharing arrangement of costs and risks has a substantial influence in positioning and improving the value indices (see Figure 8.3).

Figure 8.3 Establishing the best value



If point *a* stands for total technology acquisition cost and point *b* implies the expected transfer benefit, the value of technology may be accepted by acquirers at this cost level (65). However, considering the risks, acquirers may feel uncertain that the expected transfer gains can be completely generated and captured in the future. The actual return may only reach the level of, say, 40 (point *d*). Note that the point *d* is below the value index equal line which means costs incurred are higher than benefits that the acquirer expects to gain by its own capability. If this is the acquirers' perception of the future result they would not accept the value at the cost of 65 (point *a*), rather, they may only appreciate the value of technology at a lower level and agree to pay a maximum of 40 in order to avoid financial loss. This is particularly the case when technology is transferred in a form of a one-off transaction. Preferably, acquirers would like suppliers to share some of the costs and risks and in return share benefits in the future. In such a situation the total transfer costs are shared and acquirers only need to pay, say, 40 (point *c*) for obtaining the technology. As a result acquirers will at least gain the future benefits at the same level as cost (point *c*) while suppliers gain the benefits at the minimum between point *b* and point *c* (65-40=25) as they have born this part of the costs, should the level of 65 joint benefits be generated.

The ideal output is that the value index is above the equal line (point *e*) which means the joint transfer benefits are greater than the total cost shared by both parties. The equal line implies the basic condition that the worth of technology may be accepted (e.g. point *c* and *b*). Value indices below the equal line indicate cost ineffectiveness regarding absorption and use of transferred technology. Both sides can re-position the value index by improving the relationship between technology gains and corresponding costs.

Sharing arrangements have a significant impact on the improvement of the cost-benefit relationship in technology transfer transactions. To suppliers, sharing more cost does not only mean the payoff time changing from the present to the future, but also implies their investment is increased which would enable them to capture future return to a greater extent. The increase in cost would be worthwhile provided a greater return could be captured. To acquirers, greater sharing would reduce their acquisition cost as well as financial uncertainty, so that the relationship between immediate input and future return is improved. More importantly, a greater sharing arrangement also implies closer commitment which would lead to an enhanced joint strength. In such a case, the relative percentage of the acquirers' share of future benefits is reduced while they may still be able to capture more gains in absolute terms from the increased joint value. In most cases, the preferred approach of the acquirers has been evidently to have a lower initial capital investment (i.e. acquisition cost) with a lower percentage share of future return, rather than a higher up-front acquisition cost with higher potential returns but also greater risks.

Value index is a very useful tool to demonstrate the variation in the relationship between the extent of contribution obtained and the level of incurred cost. The relationship provides an indication that the overall ratio (value index) varies depending on how the transfer elements (i.e. transfer content, transfer features and sharing arrangement etc.) are composed in a specific collaboration arrangement. By adjusting the composition of the arrangement the value index can be improved. As the core of technology valuation is to assess how the value would be generated and shared in the technology collaboration, the means of improving the value index are: (a) to maximise the joint value by adjusting the proposed arrangement with an aim at strengthening key contributory factors. Any key contributory transfer features that were originally missed need to be added to the collaboration arrangement through negotiations; and (b) to improve cost effectiveness of the transfer by adjusting the sharing arrangement or reducing relatively unimportant transfer elements or modifying the arrangement to save costs (for example, more use of local manufacturing capability in order to reduce supplied parts from technology suppliers).

The purpose of improving the value index is to obtain a more efficient investment to return ratio by re-considering and modifying the transfer arrangement with the aim of more effectively delivering technology attributes. As a result, the contributory factors may be more enhanced, and targeted objectives may have a better chance to be achieved. If this is the case, the best value of technology and a corresponding efficient collaboration arrangement are established.

8.6.3 Measuring value in financial terms: how much is it worth?

8.6.3.1 Establishment of value in financial terms

What have been achieved so far for technology valuation include:

(i) The value of technology in the VA concept indicates the ratio between the obtained benefits from technology transfer and the associated costs. Among alternatives it reflects the worth of acquiring a certain amount of benefits at the corresponding costs for each potential transfer. The specific competitive contribution of technology is also being taken into account and reflected in value in the financial, technical and strategic dimensions. By using the method, suppliers and acquirers can make comparison between alternatives in which the costs of each proposed transfer transaction would not be isolated from the related benefits so that a meaningful judgement can be ensured.

(ii) The value index implies a relationship of importance or a percentage between the input and future output. By improving value index the ineffective cost element may be removed and the effective cost element can be more focused, coupled with an appropriate sharing arrangement and cost effective commitment, a greater joint value can be generated.

Given the improved relationship between perceived transfer benefits and required costs, suppliers and acquirers would, however, *finally* consider how much the value would be in the commercial sense. That is to establish the value of technology in directly comparable term so that the investment for technology transfer can be appraised. It should, however, be noted that the value in financial terms not only includes the financial value (i.e. the immediate increase of market sales) but should also reflect the added future financial returns from technical value and strategic value which are derived from technical and strategic enhancement.

8.6.3.2 Converting value from the VA terms to the financial terms

The key question thereby is how to convert the value from the VA term, which have been essentially used to measure the value of technology in three dimensions, into the financial terms without missing out technical and strategic aspects.

Based on the VA concept, in which value represents the relationship between acquired satisfaction of needs and associated cost, the added value can be measured as the ratio of obtained competitiveness enhancement (assessed by suppliers and acquirers) compared with associated cost. i.e.

$$\text{Added value ratio} = \frac{\text{Enhanced competitiveness / Associated cost}}{\text{Previous competitiveness /Associated cost}}$$

Considering the three value dimensions, the added value ratio of technology can be represented in financial terms as in the following examples:

Added V_f ratio i.e. the financial (or market sale) competitiveness improvement index, is

$$= \frac{\text{Increased sale in local market}}{\text{Previous sale in local market}} \text{ X } \frac{\text{Price premium}}{\text{Previous price}} \text{ X } \frac{\text{Previous cost}}{\text{Effective cost}}$$

Added V_t ratio i.e. the technical competitiveness enhancement index, is

$$= \frac{\text{Raised product features and quality}}{\text{Previous product features and quality}} \text{ X } \frac{\text{Previous cost}}{\text{Effective cost}}$$

Added V_s ratio i.e. the strategic competitiveness enhancement index, is

$$= \frac{\begin{array}{c}\text{Enhanced strategic position}\\ \text{in local market}\end{array}}{\begin{array}{c}\text{Previous strategic position}\\ \text{in local market}\end{array}} \text{ X } \frac{\begin{array}{c}\text{Enhanced strategic position}\\ \text{in world market}\end{array}}{\begin{array}{c}\text{Previous strategic position}\\ \text{in world market}\end{array}} \text{ X } \frac{\begin{array}{c}\text{Previous}\\ \text{cost}\end{array}}{\begin{array}{c}\text{Effective}\\ \text{cost}\end{array}}$$

The scores of rating of previous and enhanced competitiveness can be obtained from the value assessment in the VA term as developed above. According to that the ratio of value added to total sales is commonly used in measuring the quality of FDI (Young, 1988; Turok, 1993) or FDI-linked 'technology value' (Lan, 1996), as well as the assessment of the contributions of quality improvement to market sales shown in Table 8.5, the total value comprising three dimensions can be represented in financial term as follows:

To the owner, the total value of technology represented in the financial terms is

= PV* of [expected financial gains derived from added V_f, V_t and V_s + cost]

= PV of [market sale revenue x added ratio of ($V_f + V_t + V_s$) + cost]

= PV of [market sale revenue x added financial value ratio (1)

+ market sale revenue x added technical value ratio (2)

+ market sale revenue x added strategic value ratio (3)

+ cost of technology (4)

+ cost of transfer] (5)

where (1) = increased financial return derived from technology transfer

(2) = future added financial return derived from technological enhancement

(3) = future added financial return derived from strategic development

(4) = sum of production, distribution, and corresponding development and overhead costs etc.

(5) = transfer costs

Note*: PV means present value

To the acquirer, the total value of technology represented in the financial terms is

= PV of [expected financial gains - total associated costs]

= PV of [expected financial gains derived from added V_f, V_t and V_s - total associated costs]

= PV of [market sale revenue x added ratio of ($V_f + V_t + V_s$) - costs]

= PV of [market sale revenue x added financial value ratio (1)

+ market sale revenue x added technical value ratio (2)

+ market sale revenue x added strategic value ratio (3)

- acquisition costs (4)

- other related costs] (5)

where (1) = increased financial return derived from technology transfer

(2) = future added financial return derived from technological enhancement

(3) = future added financial return derived from strategic development

(4) = sum of contract price and consequential costs

(5) = sum of production, distribution, and corresponding overhead costs etc.

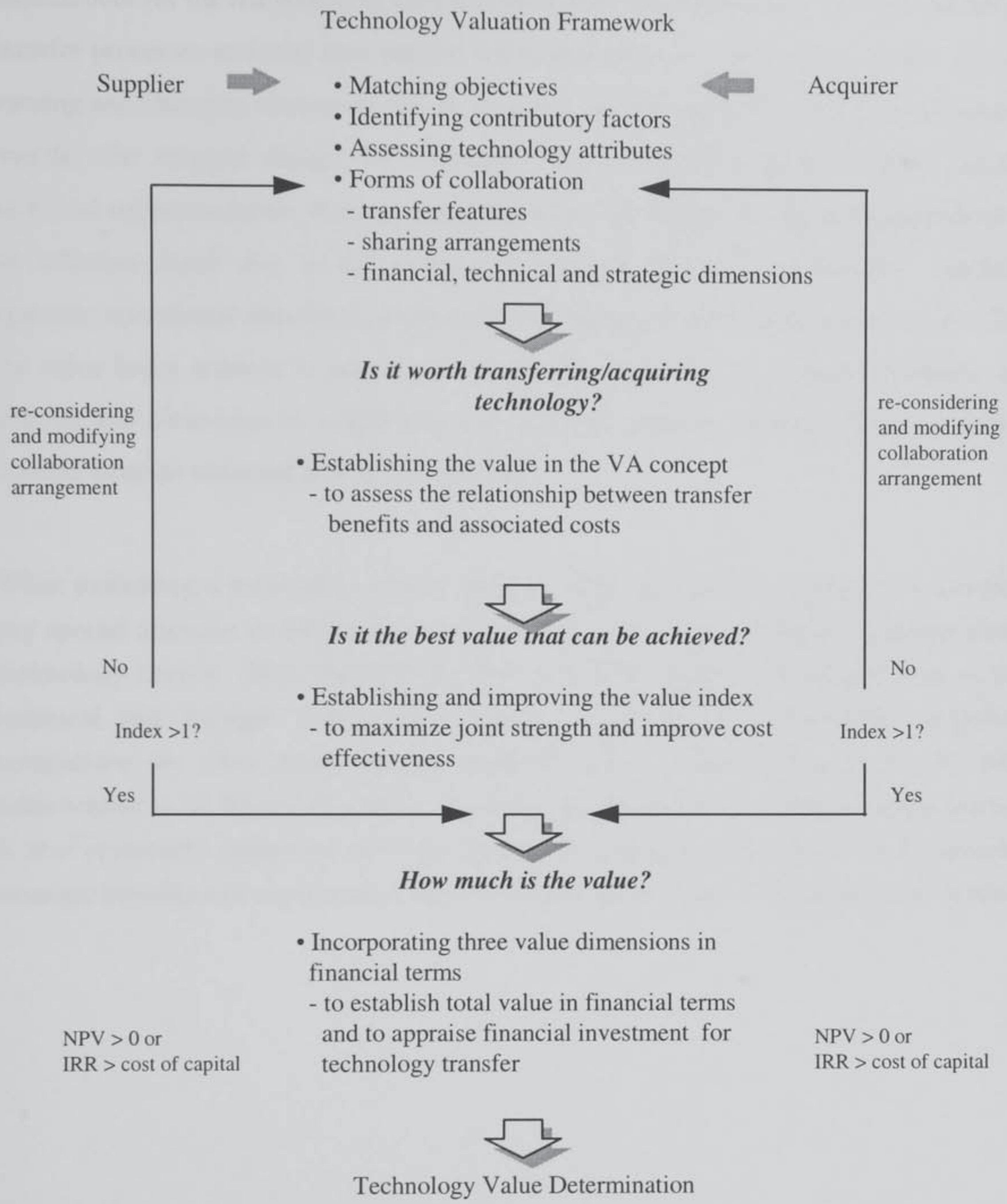
8.6.3.3 Appraisal of future financial return

To both suppliers and acquirers, technology transfer involves cost and/or capital investment if such a transfer is carried out through an on-going collaboration. If the collaboration is not in the form of a joint venture, the owner's costs are basically costs of technology and expenditures related to the transfer (assuming the development cost of technology has been amortised). To the acquirer the investment comprises the acquisition and consequential costs. As such, the ratio of each party's involvement in the total investment is substantially influenced by the cost sharing arrangement between the two parties. The owner needs to decide whether the transaction is taken as a means of gaining immediate financial return relating to its previous capital investment for the technology or as a means of re-investment in order to achieve future return. The condition of choosing the latter is that the future revenue is expected to be greater than the immediate value. Acquirers, by the same manner, also need to estimate how much future return can be generated and captured in relation to their current investment.

The transfer process of machine tool manufacturing technology normally requires a few years time. According to the survey results it needs an average 5-8 years to cover the investment. Thus when the value of technology is represented in financial terms the discounted cash flow (financial return) during the period of investment has to be considered. Hence, Net Present Value method (NPV) or Internal Rate of Return method (IRR) need to be used so that the future value of technology in financial terms can be meaningfully judged by both sides.

In summary, technology valuation comprises identifying, assessing and measuring transfer objectives, contributory factors, technology attributes, collaboration arrangements and their influences in, and implications for, the value of technology. Figure 8.4 highlights the main aspects in technology valuation framework.

Figure 8.4 Technology valuation framework



8.7 Validity Consideration of Framework Application

Suppliers and acquirers normally explore the best value of technology and form of transfer by comparing alternatives. In most of the cases in the research investigation there were often three options that were considered and compared before the final decision was made. The VA concept and method provide a useful tool for both parties to judge and compare the optimal value and forms of collaboration among the alternatives.

Technology transfer is a process of delivering systematic know-how and skills to meet the requirement for the realisation of transfer objectives. This determines the sophistication of the transfer processes and may also require the processes to be modified in order to comply with varying and changing circumstances. In the negotiation stage and even during the processes of transfer, the original design for a transfer, such as transfer phase, content, training and technical support scheme, sharing arrangement etc., may often be found inadequate to achieve an effective result due to the existing divergence between the partners' manufacturing systems, operational structures, production management and market situations etc. Therefore the value index analysis is essentially required to define the key transfer elements, scope of sharing and dimension of collaboration in order to improve transfer efficiency with greater transfer benefits obtained at less cost required.

When evaluating a technology transfer project, both suppliers and acquirers would inevitably pay special attention to the future return that they expect to generate and capture through the technology transfer. Their targeted objectives would comprise the achievement in financial, technical and strategic dimensions. However in reality the quantitative judgement and comparison are often made through financial terms. Therefore the means by which the achievement in all three dimensions can be incorporated into the financial terms is required. It is also essentially consistent with the technology valuation concept as all the technical and strategic benefits will need to be reflected through the increase of financial gains in the future.

CHAPTER NINE
SUMMARY AND CONCLUSIONS

9.1 Introduction

The chapter provides conclusions on the issue of technology valuation within the context of specific collaboration arrangements. The conclusions were drawn from the assessments carried out in all the previous chapters and were on the basis of the evidence from the questionnaire surveys and case studies.

The study of the subject literature showed the limitation of the existing knowledge to the solution of the research issue. The recognition of the technology value issue in the related ITT discussions was confined to the cost and pricing concerns which failed to reflect the nature of valuing technology, while the existing approaches related to product/technology valuation are not in the context of technology transfer hence cannot reveal the significant impact of technology collaboration on technology valuation. The gaps between the theoretical recognition and the core of the valuing technology underlay reasons for the issue remained in the ITT practice. This study was conceived as an attempt to provide an improved understanding of the value issue within the context of technology transfer arrangements.

To distinguish the meanings and implications between pricing and valuing was the first intention of this study in order to develop an improved understanding of the nature of technology valuation. From the investigations, this study identified the key factors that require consideration in technology valuation. The results indicated that a broader view of *value*, rather than price and cost, should be taken in technology valuation. This recognition paved the way to test the research hypothesis one. On this basis, the study recognised the close relationship between valuing technology and the collaboration arrangement within which the factors affecting value are linked and interacted. This shed light on testing the hypothesis two. Furthermore, the study developed a technology valuation framework which suggested that greater value can only be generated and captured through the effective transfer of required technology attributes and the best use of enhanced contributory strength towards the achievement of the mutual objectives. The following conclusions that were drawn from this study mainly refer to the research hypotheses with more implications explored.

9.2 Technology valuation is to evaluate its capability in generating the targeted return: the determination of the owner's value and transfer value

Having assessed the supplier's and acquirer's perceptions of the value of technology and their expectations from technology transfer, it was concluded that the nature of technology, differing from other products, is a capability which has a function of value creation during the process of its utilisation. Given the nature of technology, the return derived from technology depends on how such a resource is utilised. To maximise the return, the owner must choose an effective means to ensure its technology is best used. When the perceived returns from transferring technology outweigh the related costs the owner would prefer to share the use of its technology through collaborative operations.

Where costs and immediate benefits are concerned, the owner's value in conceptual terms reflects the current worth of technology at that point of the value chain by covering all the costs incurred upstream with notional profits included. However, the returns from sharing its competitive resources with others were also considered. In this regard, the cost structure of technology was established to reveal the difference of the importance between cost elements to the owner. Difficulty of determining the value of the owner's proprietary innovating know-how was identified. The strategic importance of the technology assigned by the owner has been suggested in Chapter 4 as the most important factor considered by the owner to determine the value of key know-how.

On the other hand, the owner also recognised that the capability (the nature of technology) can be jointly enhanced through technology transfer and therefore can generate greater returns in the future. The case example in Chapter 4 also demonstrated that the owner may wish to obtain the future return instead of the immediate benefits by the joint use of its technology. Affected by the acquirers' concern of transfer costs and risks, the future return to the owner is unlikely to be realised purely by means of the owner's value. A substantial part of future gains will rather be achieved through the owner's share of transfer value generated downstream. The owner's value can not even cover all the costs in certain circumstances when the future return is perceived to have a large potential and when a lower owner's value helps the owner to gain good access to the resources for generating future benefits. It has been evident that in a particular situation (e.g. HMFGW case in Chapter 4 and case F in Chapter 7) when the future transfer value and its implications are much more attractive and significant than the current worth of the technology, the owner's value can be determined well below the cost so that the access to greater future returns is ensured. This concludes that the supplier's return from technology transfer is often beyond its owner's value and that the owner's value varies substantially depending on how the supplier decides to use the technology and to share future returns. To some extent, valuing technology is even more significant for establishing a future return in the on-going value-generating activities through a collaboration than in determining the worth of technology for a one-off transaction.

To the acquirer, the acquisition of technology itself is not the benefit. Acquirers firstly expected the returns which would be generated and achieved through their downstream activities. A high positive relationship between superior product performance and greater customers' satisfaction as well as price premium was concluded, by which, a greater commercial return and market development are expected. The assessment of the factors affecting transfer value (in Chapter 5) further indicated that the returns which acquirers expected from technology transfer not only include financial gains but also technological enhancement and strategic development. The essence of acquisition of technology is to gain a potential capability so as to create a greater return by the use of it.

On the other hand, the study also recognised that, in the process of future return generation, it is also inevitable to incur costs and to be involved in risks. Cost often shows to be an indicator of how much commitment and efforts are made in the practice of delivering and exploiting such a capability. Risk on the other hand is the uncertainty of effectiveness associated with the joint use of the capability. From the case studies, the uncertainties can be summarised as:

(i) uncertainty of the control of technology (from the owner) and uncertainties of the strength of such a capability in contributing to realising the transfer objectives (from acquirers);
(ii) uncertainty that such a capability can be effectively delivered/absorbed and used; and consequently
(iii) uncertainty of the worth of the transfer/acquisition of such a capability compared with the associated costs and risks.

These uncertainties have caused the following consequences shown in case studies:

(i) the owner's competitive position may not be improved by sharing its technological advantages;

(ii) the technology may not be effectively delivered, absorbed and used;

(iii) the acquirer's technological capability may not be enhanced from the acquisition of technology;

(iv) the technology attributes may not be adequate to achieve the objectives; and

(v) the future return may not be sufficient compared with associated costs.

Putting the above factors together, it can be concluded that the value generation is influenced by how the costs and risks are shared because it implies different degrees of efforts and commitment. The complexity is, on the one hand, that the perceived high levels of costs and risks associated with the transfer of technology may prevent suppliers from being willing to establish an on-going collaboration. On the other hand, low levels of involvement may weaken the opportunity of achieving technical and strategic enhancement through a collaborative operation so that only a limited financial return can be generated and captured in the future.

From the facts that the owner's value is not the only means available to the supplier to achieve its return, and the transfer value has to be created and realised in association of costs and risks, the relationship relating to the targeted return to the corresponding costs and risks has been found to affect substantially the determination of the owner's value and transfer value. The gap between suppliers' and acquirers' perceptions of the owner's value and transfer value stands for the difference in their judgement on the extent to which the future return can be generated and captured by the joint use of technology.

Referring to hypothesis one, it can be concluded that the value of technology essentially means the returns from the use of such capability. Therefore there is a strong relationship between the value of technology and the returns from the capability it can offer to both suppliers and acquirers through technology transfer.

9.3 Technology needs to be valued within the context of the specific technology collaboration arrangement

Since the core of technology is a capability to yield beneficial output, and technology transfer is the delivery of such a capability, a judgement on the value of the technology requires consideration of how much of the capability can be delivered and used. Chapter 6 examined the impacts of terms of transfer payment and transfer arrangements on the value generation and realisation. Terms of payment show a direct impact on the value realisation in the forms of initial value and future value with varying percentage of the total return. However, the more significant result is that terms of payment also affect the value generation from the sharing arrangements for costs and risks. This was achieved in connection with the assessment of transfer arrangements, which were found to have a substantial influence on the absorption and use of the transferred technology (capability). There was considerable evidence from case studies showing that forms of transfer influence the effectiveness of the value-adding activities and consequently the future value generation in process of collaborations. The provision of adequate transfer features were critically important for improving the effectiveness of delivery of knowledge and for maximising the scope of using the complementary advantages from each party. This commitment however closely relates to the sharing arrangement for costs and risks between the partners.

In this respect, it implies that costs are not all 'bad' and hence a reduction in shared costs is not equally good if the future return can be increased and captured to a greater extent with sharing of more costs. The core of technology valuation is therefore to examine a *relationship* relating the contributions from technology and transfer arrangements to their corresponding elements of cost and risk. Where an efficient collaboration is undertaken the ratio of return to cost would be improved so a greater value of technology is achieved.

On this basis, Chapter 8 further discussed the technology valuation process within the context of collaboration. Major steps were suggested: firstly, matching objectives, in which the objective matching assessment should include the convergence of overall objectives between each party and the relative importance of the specific convergent objectives to each side's priorities. The importance of this assessment is that the mutual benefits from technology collaboration can be clearly defined and it would help to lead the collaboration towards the realisation of both parties' objectives. In this regard, case A provided a successful experience while case B demonstrated a lesson. Secondly, the assessment of contributory factors, which helps to identify the key contributors for realising transfer objectives and also to judge the technical strength or weakness of each factor. Thirdly, the assessment of technology attributes, which was used to judge the contributions that the transferred technology can make to enhancing the contributory factors for realising the transfer objectives. This assessment provides the criteria to measure the value of technology. Finally, with respect to determining the forms of collaboration, arrangements should be established in such a form whereby technology attributes can be effectively captured and best exploited, hence most of the contributory factors can be strengthened.

For this end, the overall objective of technology valuation is not to judge the worth of technology in the market, rather, it is to achieve the best use of technology and efficient collaboration. The best use of technology comprises achieving financial gains, technical improvement and strategic development. The achievement of efficient collaboration embraces creation of a stronger joint strength, enhancement of opportunities for generating greater joint benefits and improvement of capability to capture perceived benefits. Altogether it indicates that technology valuation not only involves value judgement and measurement but also includes value generation and realisation. It hence, referring to hypothesis two, concludes that valuing technology and establishing an efficient collaboration have a strong interactive relationship. The justification of the value therefore can only be made within the context of the collaboration arrangement where the value is jointly generated and shared. In parallel, the judgement of technology collaboration is made on the basis of identification which form would enable a greater value to be generated with minimum costs and least risks involved.

9.4 Three value dimensions and the interactions of achievements

The considerations of the potential financial, technological and strategic benefits by both suppliers and acquirers have clearly been shown in survey results and case studies. Hence the determination of the value requires to include all these dimensions, where the financial value, technical value and strategic value were identified and assessed.

It has been found that financial value, being represented by increased sales revenue derived from the sales of a larger quantity or a price premium advantage, is relatively easy to calculate while technical and strategic value are more difficult to measure. The consequent lack of the attention given to the measurement of technical and strategic value have shown to affect both suppliers' and acquirers' perception of the future joint value. Acquirers may not fully recognise the implication of technology attributes being offered for their development while suppliers may not see the potential contributions that acquirers can make in longer terms. Findings further indicated that the elements of technical value are often different between suppliers and acquirers, and the value that can be captured varies depending on what types of technology are transferred and what forms of collaboration arrangements are established. In a lower commitment collaboration arrangement the transfer of critical key know-how may not be involved. In such a case, the technical value to the supplier and acquirer would be a new cost-effective product but the acquirer's technological capability improvement, as an important element of the technical value, may not be fully achieved. Strategic value is the combined result of the continuous achievement of financial and technical value. It however requires a long-term partnership with more exploitation of complementary advantages which often implies a greater sharing arrangement.

Further conclusions included an interrelationship between the three value dimensions in the process of value generation. Benefits of different aspects were often found interacted and not arrive at the same time. In some cases this led to a dissatisfaction with the performance of the collaboration at some stages. On the one hand, limited financial gains may shadow the possible achievement of strategic value in the future (e.g. cases B, and E in the early stage), on the other hand, low technical enhancements may hamper the further achievement of financial value (e.g. case D), hence reduced the suppliers' enthusiasm of continuing partnership. This demonstrates the importance of recognition of the interactions between value components. The co-ordination of all these value components lies on the transfer arrangements. The operational arrangement used in Case F demonstrated a positive interactive relationship between the three value dimensions:

- Supplier achieves financial value by acquirer's initial payment for technology;
- Acquirer gains immediate technical value by product improvement;
- Both obtain further financial value from selling improved end-products in the market;

- Financial achievement enable both parties to gain further technical value;
- Technical capability enhancement creates a greater future financial value to both parties;
- A sustainable and greater financial and technical value achievement leads to realising strategic value to both parties; and
- An enhanced strategic position ensures further financial gains and technological capability improvement (see Figure 9.1).

Figure 9.1 Co-ordination of financial, technical and strategic achievements

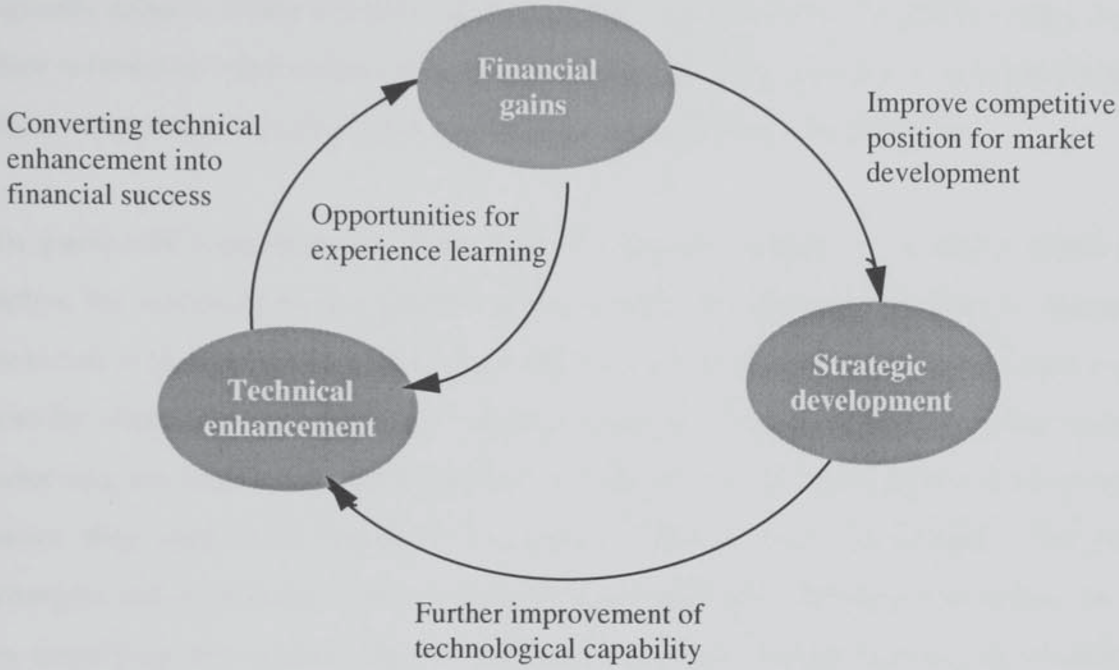


Figure 9.1 illustrates that the achievement of the value in three dimensions is interrelated over the whole process of technology transfer. Given the interaction among the three value dimensions, the overall consideration of their interactive contributions, the consequent results and the implications are required. The greater potential financial value should result from the superior technical value and long-term strategic value. On the other hand, without added financial value the further technical value and strategic value may not be achieved. A collaboration arrangement should contribute to the positive interactions of the achievement in the three value dimensions.

In summary, the value of technology is a dependent of value generation compared with associated costs and risks. The effectiveness of the use of technology is the key to enable a greater value generation at minimum costs and risks. The technology collaboration arrangement has a substantial impact on the value by determining the cost-effective ratio in the value generation processes. Technology valuation therefore requires the broad view with the aim of the best exploitation of joint strength and towards achievement of value in all financial, technical and strategic dimensions.

9.5 Considerations of practical implementations

The technology valuation framework was established on the basis that valuing technology is a dynamic process which includes value generation and realisation. Where the major factors and their interactive relationships are included, the framework provides a conceptual approach to build solutions to the value issue within the context of technology transfer.

To practically implement the framework, a company (supplier or acquirer) firstly needs to define the resources to be allocated to the transfer according to the project objectives. The next task is to establish a set of measurement criteria which should be based on the company's transfer objectives and reflect the 'quality elements' of all the key factors that contribute to achieving the targets. The measurement criteria are vitally important for valuing technology hence they need to be agreed by the project team and top management. The company's strengths and weaknesses of key elements, required for the objective realisation, are assessed by employing the criteria. On this basis, the expected transfer benefits or contributions of enhancement from the transfer can be identified. The selection of the partner would then be based on how well both parties' objectives are matched and the extent to which the company's strengths/weaknesses can be exploited/enhanced by the joint use of technology. The measurement of the enhancement is to assess the contributions that could be obtained by the joint use of resources. The factor enhancement achieved compared with the conditions of pre-transfer can be viewed as an improvement ratio, by which, the degree of objective achievement can be estimated.

At this stage, companies may need to adjust the allocation of the resources to the project because of the estimated achievement, or may need to consider alternative partners, with the aim of obtaining a greater achievement with relatively less inputs. When the obtained contributions/enhancements to costs ratio is concerned, considerations should also include changing forms of transfer arrangements. In this respect, the objective is to achieve an effective transfer and absorption of the required know-how/skills. To achieve this, provisions of more transfer features and additional cost involvement/sharing may be necessarily required. A possible difficulty when assessing the return to cost ratio is the lack of information on the detailed cost distribution associated with the provision of each transfer feature. The value index method can be used to determine the ratio on the basis of percentage. This again calls for sound and accurate criteria in order to measure the non-quantifiable elements such as technical and strategic enhancement. On the basis of measuring the technical and strategic contributions to increasing financial gains, the technical value and strategic value can be incorporated in financial terms. Finally, the value of technology is dynamically determined, whereby associated with the terms of transfer payments and arrangements should be established to meet the technical requirements, to help an effective delivery of knowledge, to maximise the use of technology attributes and to achieve a greater return to cost ratio.

9.6 Areas for further research

The immediate needs are to further investigate (a) the features of transfer arrangements and (b) the constraints that the acquirers are faced with which prevent them from achieving an effective transfer. Concerning (a), there are a variety of arrangements which have been used for the technology transfer, but the study also found that companies often treated the arrangement as a 'routine guide' rather than a particularly designed means to enhance the opportunities of greater achievement. The conditions to decide the choice among the alternative arrangements were not specifically determined. The study suggests that the features of transfer can be differently combined hence both parties' potential would be exploited with varying extent. There may be considerable potential for the development of collaboration forms whereby the performance of value-adding activities can be improved more.

As to (b), the impact from the constraints on the value generation was not explored as a focus in this study. However, the impact may be substantial if the constraints become the critical factors in transfer processes. The company's inability to control the external constraints (e.g. technology infrastructures or, more specifically, the industry integration) and/or to remove the internal constraints without delay (e.g. inadequate organisational structure for monitoring the performance of management and operations) may produce a variance, in a particular period of time, from the assessed contribution that both parties expected to obtain from their collaboration. Whether or not, and to what extent, the specifically designed transfer arrangements can reduce the impacts of the constraints so as to achieve an effective performance in the process of value generation will require further studies.

Further works include to establish a general application of the framework in other industries. Firstly, the divergence of product dependence in the value chains, features of production and technology gaps between industries may call for some special elements adding to the valuation process. Secondly, studies in other value streams require to be linked and compared. Finally, to help companies establish an appropriate value of technology and an efficient collaboration, a practical guide (e.g. a workbook) needs to be developed. The study recognised that many collaborations failed because of the higher opportunity cost of continuing the operation compared with the fast market growth, even though the operation itself did not run loss but with a limited achievement. Hence, an efficient collaboration demands proactive approaches therefore such a guide in strategic implementation and operational coordination can be critically important. Following the improved understanding of technology valuation and the establishment of the framework from this study, the guide should be developed as an easy and effective tool to use, so that in practice the improvement in value generation process and therefore an achievement of greater value can be made a deliberate rather than a random occurrence.

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APPENDIX A

METHODS TO ESTABLISH VALUE INDICES

Using the factors that were identified from questionnaire surveys to affect value, the examples of establishing acquirers' value index are shown in the following tables.

Table A.1 Method for establishing acquirers' technical value index

Contributory factors for technological competitive strength	Weight % of importance (1)	Technology attribute (2)	Risk % of reduction (3)	Expected technical enhancement (4) = (1) x (2)x[1-(3)]
Product quality and quality control	0.21	Assessment	Assessment	
Advanced and customised product design	0.20	Assessment	Assessment	
Response time to customer's requirements	0.10	Assessment	Assessment	
Technological level of product	0.09	Assessment	Assessment	
Process programming	0.09	Assessment	Assessment	
Costing control	0.09	Assessment	Assessment	
Production capability	0.08	Assessment	Assessment	
Manufacturing time	0.08	Assessment	Assessment	
Product ranges	0.06	Assessment	Assessment	
Sum	100%	Total of assessed attributes	Total rate of reduction of obtained attributes	Total of expected technology's contribution

Notes:

- *Weight* refers to the importance of contributory factors in contributing to realising the objective of technological competitive strength (source: the Chinese machine tool survey);
- *Technology attribute* refers to the assessed technology's contribution to enhancing these contributory factors;
- *Risk* refers to associated uncertainties which may reduce actual attributes obtained (see Table 9.9);
- *Expected technical enhancement* refers to the expected technical benefits derived from technology acquisition taking into risks account.

$$\text{Acquirers' technical value index} = \frac{\text{\% of technology's contribution to improving technological competitive strength}}{\text{\% of corresponding costs in total cost}}$$

Table A.2 Method for establishing acquirers' financial value index

Contributory factors for market sales	Weight % of importance (1)	Technology attribute (2)	Risk % of reduction (3)	Expected market sales improvement (4) = (1) x (2)x[1-(3)]
Product design and quality	37%	Assessment	Assessment	
Technically competent after sale service	12%	Assessment	Assessment	
Quality-price ratio	12%	Assessment	Assessment	
Quick response to customers	12%	Assessment	Assessment	
Delivery time	10%	Assessment	Assessment	
Product range	9%	Assessment	Assessment	
Sufficient supply	8%	Assessment	Assessment	
Sum	100%	Total of assessed attributes	Total rate of reduction of obtained attributes	Total of expected technology's contribution

Notes:

- *Weight* refers to the importance of contributory factors in contributing to realising the objective of increasing market sales (source: the Chinese machine tool survey);
- *Technology attribute* refers to the assessed technology's contribution to enhancing these contributory factors;
- *Risk* refers to associated uncertainties which may reduce actual attributes obtained;
- *Market sales improvement* refers to expected financial benefits from technology acquisition taking risks into account.

$$\text{Acquirers' financial value index} = \frac{\text{\% of technology's contribution to improving market sales}}{\text{\% of corresponding costs in total cost}}$$

Table A.3 Method for establishing acquirers' strategic value index

Contributory factors for strategic development	Weight % of importance (1)	Technology attribute (2)	Risk % of reduction (3)	Expected strategic development (4) = (1) x (2)x[1-(3)]
Company's reputation	0.19	Assessment	Assessment	
Technological competitiveness in domestic market	0.19	Assessment	Assessment	
High market share in domestic market	0.18	Assessment	Assessment	
Technological competitiveness in the world market	0.16	Assessment	Assessment	
High profitability	0.15	Assessment	Assessment	
Increase CNC machines export	0.13	Assessment	Assessment	
Sum	100%	Total of assessed attributes	Total rate of reduction of obtained attributes	Total of expected technology's contribution

Notes:

- *Weight* refers to the importance of contributory factors in contributing to realising the objective of strategic development (source: the Chinese machine tool survey);
- *Technology attribute* refers to technology's contribution to improving these contributory factors;
- *Risk* refers to associated uncertainties which may reduce actual attributes obtained;
- *Strategic development* refers to expected strategic benefits from technology acquisition taking risks into account.

$$\text{Acquirers' strategic value index} = \frac{\text{\% of technology's contribution for strategic development}}{\text{\% of corresponding cost in total costs}}$$

The financial value index indicates the ratio of increased market sales to related costs from technology transfer. The technical value index indicates the ratio of potential improvement of technological capability to related costs. The strategic value index indicates the ratio of strategic enhancement to the related costs. Technical and strategic value indices imply future growth of financial value if both of them are greater than one.

APPENDIX B

THE UK MACHINE TOOL QUESTIONNAIRE

MACHINE TOOL TECHNOLOGIES ASSOCIATION

Survey of Machine Tool Manufacturers Concerning Technology Transfer To China

ASTON BUSINESS SCHOOL

Note: In this questionnaire '**Technology Transfer'** refers to transfer by any means, e.g. by sale of machines and drawings, sale of drawings and training, licensing agreements, subcontracting, co-production, joint ventures etc.

Section A - For all companies to answer

A.1 What are the major products of your company?

____

A.2 Are your major product general or special purpose machine tools? Please tick.

a) General ☐ b) Special ☐

A.3 In which industries are your major customers?

____

A.4 How many employees are there in your company?* (see note below)

____

***Note**: If your company is part of a larger international or UK group, please provide the number of employees in your machine tool operation in the UK

A.5 Please scale the importance of the following factors for the competitiveness of your products (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant). Please use the full scale where appropriate.

a) ease of use and maintenance ☐
b) functionality ☐
c) reliability ☐
d) accuracy ☐
e) processing consistency ☐
f) processing productivity ☐
g) appearance ☐
h) performance/price ratio ☐
i) others (please specify) ☐

A.6 What do you consider to be the technology gap between your most advanced CNC machine tools and the nearest Chinese equivalent? Please tick as appropriate.

less than 2 years ☐ 2-5 years ☐ 5-10 years ☐ more than 10 years ☐

A.7 Compared with the price of your CNC machines when sold in China, what would be the expected price differences of equivalent Chinese made machines based on (1) transferred foreign technology and (2) local technology? Please tick as appropriate.

	Relative price of Chinese machine tools				
(1) Chinese made with foreign technology	<20% lower	20-40% lower	40-60% lower	60-80% lower	> 80% lower
(2) Chinese made with local technology	<20% lower	20-40% lower	40-60% lower	60-80% lower	> 80% lower

Section B - For companies who already have experience of transferring technology (if your company does not have transfer experience please go directly to Section C)

Note: In this section please provide details of your company's most important experience of technology transfer to China, if not, to another developing country (if you are conducting more than one transfer please give details of the most important one).

B.1 In which country is your partner (if not in China)?

____

B.2 In which year did your company transfer the technology?

____

B.3 What is the type of technology being transferred? Please tick as appropriate.

(a) product technology ☐ (b) process technology ☐
(c) product and process technology ☐

B.4 What is the form of collaboration for the transfer? Please tick as appropriate.

a) one-off sale of machine and drawings ☐
b) one-off sale of drawing and training ☐
c) licensing ☐
d) subcontracting ☐
e) co-production ☐
f) contractual joint venture ☐
g) equity joint venture ☐
h) other (please specify) ☐

B.5 What are the terms of payment for the technology provided by you? Please tick as appropriate.

a) one-off payment ☐
b) part payment at each phase of transfer ☐
c) initial payment plus future royalty payments ☐
d) payment for supply of key components (i.e. no charge for 'technology') ☐
e) share of profits from sale (i.e. no initial payment) ☐
f) others (please specify) ☐

B.6 What is the level of technology being transferred? Please tick as appropriate.

a) latest technology ☐
b) early 90s' technology ☐
c) late 80s' technology ☐
d) mid 80's technology ☐
e) earlier 80's technology ☐

B.7 What is the contract value or value of your investment if a joint venture (JV)? Please tick as appropriate.

less than £ 0.5 million ☐ £0.5-1 million ☐ £1-2 million ☐ £2-3 million ☐
£3-4 million ☐ £4-5 million ☐ more than £ 5 million ☐

B.8 How many models did the contract, or your JV investment, cover (if specified in contract)? _________

B.9 How many machines did the contract, or your JV investment, cover (if specified in contract)? _______

B.10 How many alternative partners did your company consider before the contract was signed?_________

B.11 What are the reasons for your choice of partner over the alternatives? Please tick one or more as appropriate

a) higher local market share ☐
b) better quality of currently-made product ☐
c) greater production capacity ☐
d) better marketing capability ☐
e) better quality of production equipment ☐
f) higher technological level of products ☐
g) international product quality registration ☐
h) awareness of supplier's product brand name ☐
i) others (please specify) ☐

B.12 Please scale the suitability for you of the following forms of collaboration based on your transfer experience (6 = most suitable, 5 = very suitable, 4 = suitable, 3 = fairly suitable, 2 = not very suitable, 1 = unsuitable)

a) one-off sale of machine and drawings ☐
b) one-off sale of drawings and training ☐
c) licensing ☐
d) subcontracting ☐
e) co-production ☐
f) contractual joint venture ☐
g) equity joint venture ☐
h) other (please specify) ☐

B.13 Please scale the suitability for you of the following terms of payment based on your transfer experience (6 = most suitable, 5 = very suitable, 4= suitable, 3 = fairly suitable, 2 = not very suitable, 1 = unsuitable)

a) one-off payment ☐
b) part payment at each phase of transfer ☐
c) initial payment plus future royalty payments ☐
d) payment for supply of key component ☐
e) share of returns from sale ☐
f) others (please specify) ☐

Note: Please answer the following questions ***(B14-B19)*** with respect to your <u>actual</u> transfer experience identified above

B.14 Please tick the elements in the following list included in your transfer of technology and estimate the percentage value of each within the total contract value.

<u>Breakdown of contract components supplied to your partner or JV by value</u>

	Included	%
a) sample machine	☐	
b) technology software (drawings)	☐	
c) CKD, SKD kits	☐	
d) parts and components	☐	
e) training	☐	
f) transportation	☐	
g) technical supervision	☐	
h) others (please specify)	☐	

B.15 From your experience please indicate the *approximate* time taken for the following

a) to conduct negotiations up to signing of contract ☐ years
b) to transfer technology within the agreement ☐ years
c) to realise technology in marketplace (sale of end-product) ☐ years
d) to recover your initial investment ☐ years
e) to retention of technological advantage in local market ☐ years

B.16 Please scale the following results compared with your expectations based on your transfer experience (6 = fully satisfied, 5 = very satisfied, 4 = satisfied, 3 = fairly satisfied, 2 = unsatisfied, 1 = not at all satisfied)

a) your control of the technology being transferred ☐
b) your partner's absorption of the transferred technology ☐
c) cost advantage for the transferred product ☐
d) quality of end-product made as a result of the transfer ☐
e) your partner's ability to win orders ☐
f) market sales of the transferred product ☐
g) customers' confidence (in the quality & reliability) of the transferred product ☐
h) competitiveness (quality & price) of the transferred product ☐
i) meeting customers' needs (performance) with the transferred product ☐
j) working relationship between you and your partner ☐
k) financial soundness of your local partner ☐

B.17 Please scale the following outcomes regarding the quality of the technology transfer based product made by your partner compared with your expectations (6 = fully satisfied, 5 = very satisfied, 4 = satisfied, 3 = fairly satisfied, 2 = unsatisfied, 1 = not at all satisfied)

a) ease of use and maintenance ☐
b) functionality ☐
c) reliability ☐
d) accuracy ☐
e) processing consistency ☐
f) processing productivity ☐
g) appearance ☐
h) performance/price ratio ☐
i) others (as specified in A.5) ☐

B.18 Please scale the following <u>actual</u> improvements in competitiveness in local market (from your transfer collaboration) compared with your expectations based on your transfe experience (6 = fully satisfied, 5 = very satisfied, 4 = satisfied, 3 = fairly satisfied, 2 = unsatisfied, 1 = not at all satisfied)

a) production costs reduced ☐
b) low cost component suppliers acquired ☐
c) market entry gained or market sale increased ☐
d) local customers' requirements met ☐
e) after sales service improved ☐
f) enhanced strategic position locally ☐
g) others (please specify) ☐

B.19 Please indicate the actual results in terms of cost-reduction and market sale-increase in local market from your transfer experience. Please tick as appropriate

Cost reduction		Market sale increase by value	
less than 10%	☐	less than 10%	☐
10-30%	☐	10-30%	☐
30-50%	☐	30-50%	☐
more than 50%	☐	more than 50%	☐

Section C - For all companies to answer

Note: Questions from ***C1*** - ***C8*** related to general issues of technology transfer to China. Please base your response on experience elsewhere or on judgement if have no experience of technology transfer to China.

C.1 Please *scale* the importance to you of the following possible transfer benefits (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) reduction in production costs ☐
b) acquisition of low cost local components ☐
c) market entry or increased sales ☐
d) meeting local customers' requirements ☐
e) improvement of local after sales service ☐
f) enhancement of strategic position locally ☐
g) others (please specify) ☐

C.2 Please *scale* the importance of the following attributes for realising your local market sale objectives from technology transfer (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) technological level of product ☐
b) product quality ☐
c) product range ☐
d) production capacity ☐
e) product compatibility with local market needs ☐
f) good performance/price ratio ☐
g) lower price than direct imports ☐
h) local supply of spare parts ☐
i) response time to customers' requirements ☐
j) delivery time ☐
k) technically competent after-sales service ☐
l) wide distribution channel in local market ☐
m) others (please specify) ☐

C.3 Please *scale* the importance of the following attributes for realising your cost reduction objectives from technology transfer (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) development cost reduction ☐
b) machining cost reduction ☐
c) sub assembly cost reduction ☐
d) final assembly cost reduction ☐
e) material cost reduction ☐
f) bought-out parts cost reduction ☐
g) delivery cost reduction (due to shorter distances) ☐
h) overhead cost reduction ☐
i) marketing cost reduction ☐
j) others (please specify) ☐

C.4 Please *scale* the importance of the following attributes in relation to your strategic position and objectives in the local market (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) company's reputation ☐
b) high market share in local market ☐
c) product competitiveness in the local market ☐
d) increase in exports to neighbouring countries ☐
e) high profitability ☐
f) development of local supply chain ☐
g) others (please specify) ☐

C.5 Please scale the importance of the following factors in determining your choice of potential partners. Use one of six numbers (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) local market share of potential partner ☐
b) quality of production equipment of potential partner ☐
c) quality of currently-made product by potential partner ☐
d) technological level of potential partner's products ☐
e) production capacity of potential partner ☐
f) product quality registration of potential partner ☐
g) marketing capability of potential partner ☐
j) awareness of supplier's product brand name by potential partner ☐
k) others (please specify) ☐

C.6 Please scale the strategic importance of the following know-how/skills to your company. Use one of six numbers (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) design know-how ☐
b) development know-how ☐
c) process planning and tooling know-how ☐
d) knowledge about CNC application ☐
e) machining skills ☐
f) sub-assembly skills ☐
g) final assembly skills ☐

C.7 Please scale the importance of the following factors in determining the value of technology to be transferred. Use one of six numbers (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) <u>costs</u> of producing the 'technology' * (refer to the note below) ☐
b) strategic importance to your company of the technology (i.e. proprietary or common) ☐
c) applications of technology for partner to use (i.e. general or specialised application) ☐
d) content of technology transfer package (i.e. transfer of parts or whole technology) ☐
e) training and technical support included ☐
f) worldwide reputation of your technology/product ☐
g) availability of competing technology in markets ☐

***Note**: costs of development, manufacturing and distribution etc.

C.8 Please scale the importance of the following factors in determining the <u>terms of transfer payment*</u>. Use one of six numbers (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

Note**: **'Terms of Transfer Payment'** here refers to three broad types: **'no sharing of risk and cost'** ***(e.g. one-off payment); **'some sharing of risk and cost'** (e.g. ***initial payment plus royalty payment);*** **more sharing of risk and cost** (e.g. ***payment only made through share of profit from future sale)***

a) your company's strategies for transfer (short, medium or long term) ☐
b) local market potential where your technology is transferred ☐
c) immediate transfer benefits ☐
d) perceived potential transfer benefits through collaboration with your local partner ☐
e) your willingness to share costs and risks with local partners in developing countries ☐
f) your partner's local market share ☐
g) your partner's technological capability ☐
h) your knowledge and confidence about your local partners ☐
I) others (please specify) ☐

C.9 Please indicate your production and export output in 1996 ***(approximate figures only)***

	Total	NC & CNC (among total)	Exports (among total)	NC & CNC (among exports)
Output quantity (units)				
Output value (£ million)				

C.10 Please indicate whether the following parts for CNC machines are made in-house or bought-out. Please tick as appropriate.

	Spindles	Slideways	Ballscrews	CNC systems	Drives	Hydraulic parts	Electrical Parts
In-house made							
Bought-out							

C.11 Please indicate your ***approximate*** average percentage of each cost element in relation to the total cost of the machine tools you produce.

	Conventional machine (if made)	NC or CNC machine
Development cost	%	%
Production cost	%	%
of which: - labour cost	%	%
- parts & material cost	%	%
Distribution cost	%	%
Overhead	%	%
Total	100%	100%

C.12 What is your ***approximate*** average profit margin from the sale of a machine tool?

a) conventional machine tool (if made)______% b) CNC machine tool ______%

For those companies who **HAVE HAD** technology transfer you have completed this questionnaire. We highly appreciate your kind help! Please send the completed questionnaire to MTTA. If you wish to receive the results of the survey please provide your name and address at the end of the questionnaire. We will send you the results soon after the analysis is completed.

Section D - For companies who have NOT yet had technology transfer experience

D.1 Please indicate which types of technology you may wish to transfer in the future? Please tick as appropriate.

a) product technology ☐ b) process technology ☐

c) product <u>and</u> process technology ☐

D.2 Please indicate which level of technology you may wish to transfer in the future? Please tick as appropriate

a) latest technology ☐ b) early 90s' technology ☐ c) late 80s' technology ☐

D.3 Please scale your opinion of the suitability for you of the following forms of technology transfer (6 = most suitable, 5 = very suitable, 4 = suitable, 3 = fairly suitable, 2 = not very suitable, 1 = unsuitable)

a) one-off sale of machine and drawings	☐	e) co-production	☐
b) one-off sale of drawing and training	☐	f) contractual joint venture	☐
c) licensing	☐	g) equity joint venture	☐
d) subcontracting	☐	h) other (please specify)	☐

D.4 Please scale your opinion of the suitability for you of the following terms of payment for technology transfer (6 = most suitable, 5 = very suitable, 4 = suitable, 3 = fairly suitable, 2 = not very suitable, 1 = unsuitable)

a) one-off payment	☐
b) part payment at each phase of transfer	☐
c) initial payment plus future royalty payments	☐
d) payment for supply of key components (i.e. no charge for technology)	☐
e) share of returns from sale (i.e. no initial payment)	☐
f) others (please specify)	☐

You have completed this questionnaire. We much appreciate your help! Please send the completed questionnaire to MTTA. If you wish to receive the results of the survey please provide your name and address at the end of the questionnaire. We will send you the results soon after the analysis is completed.

Name of respondent	
Company name & Address	
Post code	
Tel No:	
Fax No:	

APPENDIX C

THE CHINESE MACHINE TOOL QUESTIONNAIRE

Survey of Chinese Machine Tool Manufacturers Concerning Technology Import and Valuation

1. General information

1.1 What is the status of your company?______________________________

1.2 What are the major products of your company?______________________________

1.3 Which industries are your major users ?______________________________

1.4 (a) How many *on-duty* employees are there in your company?____________________

(b) How many employees are directly involved in manufacturing machine tools? _______

2. Assessment and Expectations

2.1 What do you think to be the time gap between most advanced Chinese made and most advanced foreign made CNC machine tools? Please tick as appropriate.

Less than 2 years ☐ 2-5 years ☐ 5-10 years ☐ More than 10 years ☐

2.2 Please scale the following factors concerning imported machines, domestically made machines based on technology transfer form foreign companies and Chinese made machine tools. Use one of ten numbers (10 = fully satisfied to 1 = not at all satisfied). Leave columns blank where not appropriate.

	Imported machines	Domestically made with foreign technology	Chinese machines
Ease of use and maintenance			
Functionality			
Reliability			
Accuracy			
Consistency			
Processing productivity			
Appearance			
Others please specify			

2.3 If the price of Chinese CNC machine tool is 100% what are your expected price differences of equivalent Chinese made machines based on technology transfer form foreign companies and directly imported? Please tick as appropriate.

Chinese made with own technology	100%							
Chinese made with foreign technology (general purpose CNC machines)	<20% higher	20-40% higher	40-60% higher	60-80% higher	80-100% higher	100-200% higher	200-300% higher	>300% higher
Directly imported (general purpose CNC machine tools)	<20% higher	20-40% higher	40-60% higher	60-80% higher	80-100% higher	100-200% higher	200-300% higher	>300% higher
Chinese made with foreign technology (special purpose CNC machines)	<20% higher	20-40% higher	40-60% higher	60-80% higher	80-100% higher	100-200% higher	200-300% higher	>300% higher
Directly imported (special purpose CNC machine tools)	<20% higher	20-40% higher	40-60% higher	60-80% higher	80-100% higher	100-200% higher	200-300% higher	>300% higher

2.4 (A) Please *scale* the importance of the following factors into ***six*** levels based on their influence on product quality in the first column (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant). Please use full scale when appropriate.

(B) Please indicate your current situation of the following factors comparing with foreign machine tool companies in developed countries in the second column (5 = you have advantages, 4 = in an equivalent situation, 3 = you have slight disadvantages, 2 = you have fairly large disadvantages, 1 = you have very large disadvantages)

	Importance	Situation
a) Product design know-how	☐	☐
b) Customised design know-how	☐	☐
c) Process programming know how	☐	☐
d) CNC know-how	☐	☐
e) Processing skills for key components	☐	☐
f) Assembly skills	☐	☐

2.5 Please scale importance of the following factors in determining product competitiveness (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) Ease of use and maintenance ☐
b) Functionality ☐
c) Reliability ☐
d) Accuracy ☐
e) Consistency ☐
f) Processing productivity ☐
g) Appearance ☐
h) Quality price ratio ☐
i) Other please specify ☐

3. Benefits of technology imports and factors affecting selection of suppliers

3.1 Please *scale* the importance/desirability of the following possible transfer benefits (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) Product level (technological) can be upgraded ☐
b) The existing product range can be enlarged ☐
c) Product quality can be improved ☐
d) Domestic market sale can be increased ☐
e) A new domestic market niche can be developed ☐
f) Exports can be increased ☐
g) Company/product image can be improved ☐
h) Production costs can be reduced ☐
i) Manufacturing time can be reduced ☐
j) Technical development capability can be improved ☐
k) Production management can be improved ☐
l) Others please specify ☐

3.2 Please scale the importance of the following factors in determining your choice of technology suppliers. Use one of six numbers (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) Greater advanced technology provided ☐
b) Key know-how transferred ☐
c) Inclusion of training ☐
d) Key components supplied ☐
e) Extensive product range included ☐
f) Favourable terms of payment ☐
g) Appropriate forms of collaboration ☐
h) Technology being kept updated ☐
i) Lower price ☐
j) Access to world market provided ☐
k) High demand for the product in local markets ☐
i) Supplier's good reputation ☐
m) Awareness of supplier's product brand name ☐
n) Others please specify ☐

3.3 Has your company had the experiences of technology import before?

Yes ☐ No ☐

If 'Yes' please continue to answer the following questions.

If 'No' please skip to section 7.

4. Experiences of technology imports

4.1 Please provide some details of your company's last two technology imports (refer to notes below)

Year of import	Company & country of origin	Type of technology (refer to note*[1])	Purpose of technology (refer to note*[2])	Form of collaboration (refer to note*[3])	Terms of payment (refer to note*[4])	Level of technology (refer to note*[5])	Approximate value of contract (refer to note*[6])	Number of alternatives you looked at (if any)	Reasons for choice over alternatives (refer to note*[7])

Note on type*[1]
(1) For making general-purpose M/C tools (2) For making special purpose M/C tools

Note on purpose*[2]
(1) Product technology (2) Process technology (3) Product and process technology

Note on forms of collaboration*[3]
(1) Outright purchase of equipment with drawing (2) Outright purchase of drawing with training (3) Licensing
(4) Co-production (5) Subcontracting (6) Contractual JV (7) Equity JV

Note on terms of payment*[4]
(1) Up-front payment (2) Instalment on each phase (3) Initial payment plus future royalty payment
(4) Payment for key components (5) Future payment on sale (6) Others please specify

Note on level of technology*[5]
(1) Latest technology (2) Early 90s' technology (3) Late 80s' technology

Note on contact value*[6]

(1) < US$1 million (2) US$1-2 million (3) US$2-3 million (4) US$3-4 million (5) US$4-5 million (6) > US$5 million

Note on reasons*[7]

(1) Greater technological advantage (2) Key know-how transferred
(3) Inclusion of training (4) Key components supplied
(5) Extensive product range included (6) Favourable terms of payment
(7) Appropriate forms of collaboration (8) Technology being kept updated
(9) Lower price (10) Access to world market provided
(11) High demand for the product in local markets (12) Supplier's good reputation
(13) Awareness of supplier's product brand name (14) Others please specify

4.2 Please scale the suitability of the forms for collaboration that you considered in your last two transfer experiences (1 = imperative suitable, very suitable, 3 = suitable, 4 = fairly suitable, 5 = not very suitable, 6 = unsuitable)

(1) Outright purchase of equipment with drawing (2) Outright purchase of drawing with training (3) Licensing
(4) Co-production (5) Subcontracting (6) Contractual JV (7) Equity JV

4.3 Please scale the suitability of the forms for collaboration that you considered in your last two transfer experiences (1 = imperative suitable, very suitable, 3 = suitable, 4 = fairly suitable, 5 = not very suitable, 6 = unsuitable)

(1) Up-front payment (2) Instalment on each phase (3) Initial payment plus future royalty payment
(4) Payment for key components (5) Future payment on sale (6) Others please specify

5. Importance of cost components from your last two transfer experiences

5.1 Please tick among the following the cost components which actually occurred in your last two transfer experiences and estimate the percentage of each in the total transfer costs.

Contract items	Experience 1 occurred	Experience 1 %	Experience 2 occurred	Experience 2 %
a) Cost of purchasing equipment	☐	☐	☐	☐
b) Cost of purchasing technology (drawings)	☐	☐	☐	☐
c) Cost of purchasing parts/components	☐	☐	☐	☐
d) Cost of training	☐	☐	☐	☐
Additional costs				
e) Cost of purchasing fitting equipment	☐	☐	☐	☐
f) Cost of purchasing spare parts/components	☐	☐	☐	☐
g) Extra cost of training	☐	☐	☐	☐
h) Marketing cost	☐	☐	☐	☐
I) Cost of organisational changes	☐	☐	☐	☐

5.2 Please indicate the following time taken (approximately) in your last two transfer experiences

	Experience 1	Experience 2
a) Time taken to conduct negotiations	☐ years	☐ years
b) Time taken to transfer within agreement	☐ years	☐ years
c) Time taken to realise technology in marketplace	☐ years	☐ years
d) Time taken to recover your investment cost	☐ years	☐ years
e) Time of the technology retaining its advantage in local market	☐ years	☐ years

6. Results compared with expectations in your last two transfer experiences

6.1 Please scale the following results compared with your expectations in your last two transfer experiences (6 = fully satisfied, 5 = very satisfied, 4 = satisfied, 3 = fairly satisfied, 2 = unsatisfied, 1 = not at all satisfied)

	Experience 1	Experience 2
a) Absorption of technology	☐	☐
b) Effective use of technology	☐	☐
c) Supply of key components	☐	☐
d) Solution to technical problems	☐	☐
e) Quality of end-product	☐	☐
f) Customer's confidence (quality & reliability)	☐	☐
g) Competitive product (quality & price)	☐	☐
h) Meet customers' needs (performance)	☐	☐
i) Understanding and trust between partners	☐	☐
j) 'Goodness' of collaboration	☐	☐
k) Financial stability of foreign partners	☐	☐

6.2 Please scale the following results (product improvement) compared with your expectations in your last two transfer experiences (6 = fully satisfied, 5 = very satisfied, 4 = satisfied, 3 = fairly satisfied, 2 = unsatisfied, 1 = not at all satisfied)

	Experience 1	Experience 2
a) Ease of use and maintenance	☐	☐
b) Functionality	☐	☐
c) Reliability	☐	☐
d) Accuracy	☐	☐
e) Consistency	☐	☐
f) Processing productivity	☐	☐
g) Appearance	☐	☐
h) Quality price ratio	☐	☐
i) Other please specify	☐	☐

6.3 Please scale the following results (competitiveness improvement) compared with your expectations in your last two transfer experiences (6 = fully satisfied, 5 = very satisfied, 4 = satisfied, 3 = fairly satisfied, 2 = unsatisfied, 1 = not at all satisfied)

	Experience 1	Experience 2
a) Product level (technological) can be upgraded	☐	☐
b) The existing product range can be enlarged	☐	☐
c) Product quality can be improved	☐	☐
d) Domestic market sale can be increased	☐	☐
e) A new domestic market niche can be developed	☐	☐
f) Exports can be increased	☐	☐
g) Company/product image can be improved	☐	☐
h) Production costs can be reduced	☐	☐
i) Manufacturing time can be reduced	☐	☐
j) Technical development capability can be improved	☐	☐
k) Production management can be improved	☐	☐
l) Others please specify	☐	☐

7. Objectives of technology imports and attributes for realising objectives

7.1 Please *scale* the importance of the following objectives for technology imports (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) To improve technological capability	☐
b) To gain access to the world market	☐
c) To increase domestic market sale	☐
d) For long-term strategic development	☐
d) Others please specify	☐

7.2 Please *scale* the importance of the following attributes for realising your market sales (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) Upgrading technological level of products ☐
b) Improving product quality ☐
c) Enlarging product range ☐
d) Sufficient amount of supply ☐
e) Low price with low profit margin ☐
f) Price-quality ratio with higher profit margin (price premium) ☐
g) Delivery time ☐
h) After sales service ☐
i) Customised designs ☐
j) Product quantity ☐
k) Quick response to customers ☐
l) Other please specify ☐

7.3 Please *scale* the importance of following criteria for realising your overall technology capability (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) Advanceness of design ☐
b) Customised design ☐
c) Response time to customer's requirement ☐
d) Process programming ☐
e) Production capacity ☐
f) Technologic level of product ☐
g) Product quality ☐
h) Product ranges ☐
i) Manufacturing time ☐
j) Quality control ☐
k) Costing control ☐
l) Other please specify ☐

7.4 Please *scale* the importance of the following attributes for realising your exports (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) Your own channel to the world market ☐
b) Supplier's reputation in the world ☐
c) Supplier's distribution channel (means and extent of use by acquirers) ☐
d) Joint brand name ☐
e) Product quality standard ☐
f) Competitive price ☐

7.5 Please *scale* the importance of the following attributes in relation to your strategic development (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = not relevant).

a) Company's reputation ☐
b) High market share in domestic market ☐
c) Technological competitiveness in the Chinese market ☐
d) Technological competitiveness in the world market ☐
e) Increase of CNC machines in export ☐
f) High profitability ☐
g) Other please specify ☐

8. Product Information (if any information is commercially confidential please feel free to leave spaces blank)

8.1 Please indicate your production and export output in 1996 (approximate figures only)

	Total	NC & CNC (among total)	Export (among total)	NC & CNC (among exports)
Output quantity	(sets)	(sets)	(sets)	(sets)

8.2 Please indicate which of the following are your key components for producing machine tools and where they made? Please tick as appropriate.

	Spindles	Slideways	Ballscrews	Cnc systems	Drives	Hydraulic parts
NC or CNC machines:						
- in-house made						
- bought-out in China						
- imported						

8.3 Please indicate your averaged percentage of each cost in relation to the total cost of a machine tool (please provide your best estimate).

	Conventional machine	NC or CNC machine
Development cost (if any)	(%)	(%)
Production cost	(%)	(%)
of which: - labour cost	(%)	(%)
- parts & material cost	(%)	(%)
Distribution cost	(%)	(%)
Overhead	(%)	(%)

For those companies who **HAVE HAD** technology import experiences (i.e who have answered questions from section 1 to 8, you have completed this questionnaire. We highly appreciate your kind help! Please send the completed questionnaire to Wang Xingming at Renmin University. If you wish to have the result of the survey please write down your name and company address at the end of the questionnaire. We will send to you the result soon after the analysis completed.

For those companies who have **NOT** had technology import experiences (i.e. who have not answered questions from in section 4 to 6, pleases continue to answer section 9.

9. Future intentions of technology imports (for companies who have not had experiences of technology import only)

9.1 Please indicate which types of technology you wish to acquire in the future? Please tick as appropriate in the following heading (A) and (B).

(A) For making general-purpose M/C tools ☐ For making special purpose M/C tools ☐

(B) Product technology ☐ Process technology ☐ Product and process technology ☐

9.2 Please indicate which level of technology you wish to acquire in the future? Please tick as appropriate

Latest technology ☐ Early 90s' technology ☐ Late 80s' technology ☐

9.3 Please scale the suitability of the following forms of technology import
(6 = imperatively suitable, 5 = very suitable, 4 = suitable, 3 = fairly suitable,
2 = not very suitable, 1 = unsuitable)

Outright purchase of equipment with drawing ☐
Outright purchase of drawing with training ☐
Licensing ☐
Co-production ☐
Subcontracting ☐
Contractual JV ☐
Equity JV ☐

9.4 Please scale the suitability of the following terms of payment for technology import
(6 = imperatively suitable, 5 = very suitable, 4 = suitable, 3 = fairly suitable,
2 = not very suitable, 1 = unsuitable)

Up-front payment	☐	Instalment on each phase	☐
Initial payment plus future royalty payment	☐	Payment for key components	☐
Future payment on sale	☐	Others please specify	☐

You have completed this questionnaire. We highly appreciate your kind help! Please send the completed questionnaire to professor Wang Xingming at Renmin university. If you wish to have the result of the survey please write down your name and company address at the end of the questionnaire. We will send to you the result soon after the analysis completed.

APPENDIX D

THE CHINESE MACHINE TOOL USER QUESTIONNAIRE

Comparison Between Foreign And Chinese Machines

1. General information

1.1 What is the status of your company ? (ownership/JV etc.)____________________

1.2 What are the major products of your company?___________________________

1.3 What are your main markets? (if industrial products which industries) __________

1.4 How many employees are there in your company?_________________________

1.5 Please indicate your production and export output in 1996

	Total	Export (if any) (among total)
Output quantity	(units)	(units)
Output value	(RMB)	(US$)

1.6 What are your percentages of imported machine tools and Chinese made machines based on technology transfer from foreign companies (including those made in foreign joint ventures)?

	% in total quantity	% in total value (estimated)
Imported machines		
Chinese TT based machines		

2. Assessment and Expectations of Chinese and Foreign Machine Tools

2.1 What do you consider to be the time gap between the latest Chinese made (with Chinese technology) and equivalent foreign made conventional and CNC machine tools? Please tick as appropriate.

Conventional machine tools

Less than 2 years ☐ 2-5 years ☐ 5-10 years ☐ More than 10 years ☐

CNC machine tools

Less than 2 years ☐ 2-5 years ☐ 5-10 years ☐ More than 10 years ☐

2.2 If the price (including local taxes) of a Chinese **general purpose CNC** machine tool (including Chinese control) is equal to 100% what would be your expected price of....

a) An equivalent Chinese made machine based on TT from a foreign company and

b) A directly imported equivalent machine tool (excluding import tax)? Please tick as appropriate

Price of Chinese made with own technology	100%							
a) Price of Chinese with TT from foreign co.	<20% higher	20-40% higher	40-60% higher	60-80% higher	80-100% higher	100-200% higher	200-300% higher	>300% higher
b) Price of directly imported	<20% higher	20-40% higher	40-60% higher	60-80% higher	80-100% higher	100-200% higher	200-300% higher	>300% higher

2.3 If the price (including local taxes) of a Chinese **special purpose (CNC)** machine tool (including Chinese control) is equal to 100% what would be your expected price of .....

a) An equivalent Chinese made machine based on TT from a foreign company and

b) A directly imported equivalent machine tool (excluding import tax)? Please tick as appropriate

Price of Chinese made with own technology	100%							
a) Price of Chinese with TT from foreign co.	<20% higher	20-40% higher	40-60% higher	60-80% higher	80-100% higher	100-200% higher	200-300% higher	>300% higher
b) Price of directly imported	<20% higher	20-40% higher	40-60% higher	60-80% higher	80-100% higher	100-200% higher	200-300% higher	>300% higher

3. Experience with imported foreign made machine tools and Chinese made machines based on TT from foreign companies

3.1 If you have purchased imported foreign made machine tools please provide details of your last two purchases.

Year of purchase	Company and country of origin	Type of machine tool (refer to note*1)	Level of machine tool (refer to note*2)	Price of machine tool excl. imp. tax (US$)	Number of alternatives you looked at if any (refer to note*3)	Product reasons for choice (refer to note*4)	Supplier reasons for choice (refer to note*5)

Please indicate the amount of import tax if paid Machine 1. ____________________
Machine 2. ____________________

3.2 If you have purchased Chinese made machine tools based on TT from foreign companies please provide details of your last two purchases.

Year of purchase	Company name	Type of machine tool (refer to note*1)	Level of machine tool (refer to note*2)	Price of machine tool (US$)	Number of alternatives you looked at if any (refer to note*3)	Product reasons for choice (refer to note*4)	Supplier reasons for choice (refer to note*5)

3.3 If you have purchased Chinese made machine tools based on Chinese technology please provide details of your last two purchases.

Year of purchase	Company name	Type of machine tool (refer to note*1)	Level of machine tool (refer to note*2)	Price of machine tool (US$)	Number of alternatives you looked at if any (refer to note*3)	Product reasons for choice (refer to note*4)	Supplier reasons for choice (refer to note*5)

For notes on completing above tables please see next page.

Notes on completing question 3

Note on type*[1] (Please use appropriate number in the table)
(1) General-purpose M/C tools (2) Flexible manufacturing systems
(3) Stand-alone special purpose M/C tools (3) Special purpose transfer line

Note on level of technology*[2] (Please use appropriate number in the table)
(1) Latest technology (2) Early 1990s technology
(3) Late 1980s technology (4) Mid 1980s technology

Note on number of alternatives*[3]
Please provide the number of other machines considered when making your purchase.

Note on product reasons*[4] (Please use appropriate number in the table)

1) Higher functionality (e.g. Automation, flexibility and optional features)
2) Higher reliability
3) Higher accuracy
4) Greater ease of use and maintenance
5) Higher consistency
6) Higher processing productivity
7) Better appearance
8) Lower price
9) Better performance and quality to price ratio

Note on supplier reasons*[5]

1) Technological know-how
2) Inclusion of training
3) Inclusion of technical support
4) Quick delivery
5) Ability to customise machines
6) Ability to provide turnkey projects (i.e. Whole production line)
7) Quality registration (e.g. Iso9000)
8) Reputation among your industry
9) Product warranty features

4. Objectives of buying machine tools

4.1 Given your company's current priorities, please *scale* the importance of your objectives when buying machine tools.

Use one of *six* numbers (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = unimportant and/or not relevant).

a) To produce new products ☐
b) To produce higher quality products ☐
c) To improve quality consistency ☐
d) To increase production capacity ☐
e) To reduce processing time ☐
f) To meet customers' specific requirements ☐
g) To reduce manufacturing cost ☐
h) Others (please specify) ______________________ ☐

4.2 From your buying experience in question 3 please *scale* the extent to which purchases of imported machine tools, domestically made machines based on TT from foreign companies and Chinese machine tools can contribute to meeting your objectives.

Use one of numbers 10 to 0 (10 = full contribution to meeting objective, 1 = no contribution to meeting objective and 0 = objective not relevant). Leave columns blank where not appropriate.

	Imported machines	Domestically made with foreign technology	Chinese machines
To produce new products			
To produce higher quality products			
To improve quality consistency			
To increase production capacity			
To reduce processing time			
To meet customers' specific requirements			
To reduce manufacturing cost			
Others (as specified)			

5. Importance of Factors when Buying Machine Tools and Experience of Performance Against Expectations

5.1 Please *scale* the importance of the following **product** factors that you consider when buying machine tools. Use one of ***six*** numbers (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = unimportant and/or not relevant). Please use full scale when appropriate

a) High functionality (e.g. Automation, flexibility and optional features) ☐
b) High reliability ☐
c) High accuracy ☐
d) Ease of use and maintenance ☐
e) High consistency ☐
f) High processing productivity ☐
g) Good appearance ☐
h) Low price ☐
i) Performance and quality to price ratio ☐
j) Others please specify ______________________________ ☐

5.2 From your buying experience in question 3, please *scale* the following **product** factors concerning imported machines, domestically made machines based on TT from foreign companies and Chinese machine tools.

Use one of ten numbers (10 = fully satisfied to 1 = not at all satisfied). Leave columns blank where not appropriate.

	Imported machines	Domestically made with foreign technology	Chinese machines
High functionality			
High reliability			
High accuracy			
Ease of use and maintenance			
High consistency			
High processing productivity			
Good appearance			
Low price			
Performance/quality to price ratio			
Others (as specified above)			

5.3 Please *scale* the importance of the following factors in determining your choice of **machine tool supplier**.

Use one of *six* numbers (6 = imperative, 5 = very important, 4 = important, 3 = fairly important, 2 = not very important, and 1 = unimportant and/or not relevant).

a) Technological know-how ☐
b) Inclusion of training ☐
c) Inclusion of technical support ☐
d) Quick delivery ☐
e) Ability to customise machines ☐
f) Ability to provide turnkey projects (i.e. Whole production line) ☐
g) Quality registration (e.g. Iso9000) ☐
h) Reputation among your industry ☐
i) Product warranty features ☐
j) Others (please specify) ______________________ ☐

5.4 From your buying experience in question 3, please *scale* the following **supplier** factors concerning imported machines, domestically made machines based on TT from foreign companies and Chinese machine tools.

Use one of ten numbers (10 = fully satisfied to 1 = not at all satisfied). Leave columns blank where not appropriate.

	Imported machines	Domestically made with foreign technology	Chinese machines
Technological know-how			
Inclusion of training			
Inclusion of technical support			
Quick delivery			
Ability to customise machines			
Ability to provide turnkey projects			
Quality registration			
Reputation among your industry			
Product warranty features			
Others (as specified)			